STUDY OF MORPHOLOGY OF ABDOMINAL AORTA IN 50 SPECIMENS

by Karpagajothi J 20107101 M.D. Anatomy

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A STUDY OF MORPHOLOGY OF ABDOMINAL AORTA IN 50 SPECIMENS

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CHENNAI- 600 032
TAMILNADU

CERTIFICATE

This is to certify that this dissertation titled **"STUDY OF MORPHOLOGY OF ABDOMINAL AORTA IN 50 SPECIMENS "** is a bonafide work of **Dr.J.KARPAGAJOTHI**, a student in M.D. Anatomy, Branch XXIII in partial fulfillment of the requirements for the award of MD degree by the Tamilnadu Dr.M.G.R. Medical University.

Dr.V.RAJARAM.,M.S.,D.L.O
Professor,
Institute of Anatomy,

Dr.I.JAYARAJ.,M.S.,D.L.O
Director & Professor,
Institute of Anatomy,

Madurai medical college,

Madurai.

Madurai medical college,

Madurai.

DECLARATION

I, **Dr.J.KARPAGAJOTHI**, solemnly declare that the dissertation titled "**STUDY OF MORPHOLOGY OF ABDOMINAL AORTA IN 50 SPECIMENS "** has been prepared by me.

This is submitted in partial fulfillment of the regulations for the award of MD Anatomy degree examination to be held in April-2013.

This work has not formed the basis for the award of any other degree or diploma to me previously from any other university.

Place : Madurai

Dr.J.KARPAGAJOTHI

Date : 22.12.2012

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CONTENTS

LEGAND

AA	-	**ABDOMINAL AORTA**
CA	-	**CELIAC AXIS**
SMA	-	**SUPERIOR MESENTERIC ARTERY**
IMA	-	**INFERIOR MESENTERIC ARTERY**
URRA	-	**UPPER RIGHT RENAL ARTERY**
LRRA	-	**LOWER RIGHT RENAL ARTERY**
ULRA	-	**UPPER LEFT RENAL ARTERY**
LLRA	-	**LOWER LEFT RENAL ARTERY**
RGA	-	**RIGHT GONADL ARTERY**
ULGA	-	**UPPER LEFT GONADAL ARTERY**
LLGA	-	**LOWER LEFT GONADAL ARTERY**
IPA	-	**INFERIOR PHRENIC ARTERY**
CCMT	-	**COMMON CELIACO MESENTERIC TRUNK**
KINK	-	**KINKING**
RRA	-	**RIGHT RENAL ARTERY**
LRA	-	**LEFT RENAL ARTERY**
MSA	-	**MEDIAN SACRAL ARTERY**
LA	-	**LUMBAR ARTERY**
MSA	-	**MIDDLE SUPRA RENAL ARTERY**

LV - LUMBAR VERTEBRA

BL1 - BODY OF 1ST LUMBAR VERTEBRA

BL3 - BODY OF 3RD LUMBAR VERTEBRA

BL4 - BODY OF 4TH LUMBAR VERTEBRA; LL4 – LOWER BORDERS OF 4TH LUMBAR VERTEBRA

L1 -1ST LUMBAR VERTEBRA

L1-L2 -INTERVERTEBRAL DISC BETWEEN 1ST LUMBAR AND 2ND LUMBAR VERTEBRA

L2 -2ND LUMBAR VERTEBRA

L2-L3 -INTERVERTEBRAL DISC BETWEEN 2ND LUMBAR AND 3RD LUMBAR VERTEBRA

L3 - 3RD LUMBAR VERTEBRA

L3-L4 - INTERVERTEBRAL DISC BETWEEN 3RD LUMBAR AND 4TH LUMBAR VERTEBRA

L4 - 4TH LUMBAR VERTEBRA

L4-L5 -INTERVERTEBRAL DISC BETWEEN 4TH LUMBAR AND 5TH LUMBAR VERTEBRA

LL1 - **LOWER BORDER OF 1ST LUMBAR VERTEBRA**

LL3 - **LOWER BORDER OF 3RD LUMBAR VERTEBRA**

T12 - L1 - **INTERVERTEBRAL DISC BETWEEN 12TH THORACIC AND 1ST LUMBAR VERTEBRA**

T12 - **12THTHORACIC VERTEBRA**

INTRODUCTION

Anatomical knowledge of a major blood vessel is of immense significant to all as aptly quoted by Malsted as "The best way to

avoid injury to blood vessels is to know them, and to know how, when and where to ligate them properly".

Responsibility for teaching Anatomical variations lies with the anatomist. Anatomical variations for the Abdominal Aorta are not infrequent. Knowledge of existing aberration is important in planning and conducting surgical and radiological procedures.

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The abdominal aorta is the continuation of the thoracic aorta after the twelfth thoracic vertebra (T12) until fourth lumbar vertebra (L4) where it divides into left and right common iliac arteries.

It serves as the main arterial blood supply vehicle for all the abdominal cavity organs, anterior, posterior, lateral, and the roof of abdominal wall, lower limbs as well as the male and female genitals.

Knowing the morphology of Abdominal Aorta is important with regards to renal trauma, surgery, radiological imaging and surgical treatment of abdominal aortic aneurysms.

The present study is also helpful in adopting the correct procedures for treatment of vascular pathology.

According to Gray's Anatomy (40th edition 2008) the abdominal aorta begins at the median aortic hiatus of diaphragm anterior to lower border of twelfth thoracic vertebra and thoracolumbar intervertebral disc and descends anterior to the lumbar vertebrae to end at the lower border of fourth lumbar vertebra a little to the left of midline by diving into two common iliac arteries.

Branches of abdominal aorta :

Branches of abdominal aorta are described as

- **Anterior unpaired visceral branches: Celiac artery, superior mesenteric artery, Inferior mesenteric artery- supply the derivatives of gastro intestinal tract.**
- **Lateral Paired visceral branches : Renal artery, Gonadal artery, supra renal artery -supply Kidney, Gonads, Suprarenal gland.**
- **Lateral Paired Parietal branches: Inferior Phrenic arteries, Lumbar arteries- supply roof, bodywalls, vertebral column, spinal cord.**

- **Dorsal branch- Median sacral artery which is known as Continuation of abdominal aorta anostomoses with lateral sacral artery.**

The variations in the morphology of abdominal aorta and its branches are of considerable interest as its tapering geometry is crucial in the pathogenesis of vascular disease eg. Atherosclerosis and aneurysm formation. The present study of morphology of abdominal aorta is helpful in regards to diagnosis and treatment not only for surgeons but also to others.

AIM OF STUDY

To study the morphology of abdominal aorta in 50 specimens with special focus on the Morphometric measurements of abdominal aorta .

REVIEW OF LITERATURE

- Study of Abdominal Aorta dates long back when **Thane (1892), Monguidie (1893) Schwalbe and Pfitaner (1893)** studied the level of bifurcation of abdominal aorta.

- The ventral branches of abdominal aorta were later studied by various workers **Corsy and Aubert (1913), Lipshutz (1917) Ssoson - Jarosche -Witsch (1926), Adachic (1928), Tsukamoto(1929), Heidsielk(1928), Taniguchi (1931) , George (1935), Anson and M'c Vay (1936), Feller wood Burne (1960) Cauldwell & Anson (1943), Thoreak (1954)** and various workers studied the abdominal aorta and its branches.

- **S.R.Sachithanadam (1987)** (Madurai Medical College) studied the ventral branches of abdominal aorta.

- **Neil Pennington et al (2005), Songur et al (2010), Prakash et al (2011)** studied the abdominal aorta and its branches.

- **George Ruggles (1935)** studied in detail about the topographical relationships of unpaired visceral branches of abdominal aorta in 100 cadavers. They reported the mean vertebral level of ventral branches of abdominal aorta and its bifurcating level as

    - Celiac axis - first lumbar vertebra (L1)
    - Superior mesenteric artery – opposite to lower borders of first lumbar vertebra (LL1)
    - Inferior mesenteric artery- opposite to body of third lumbar vertebra (BL3)
    - Aortic Bifurcation – Lower third of fourth lumbar vertebra (LL4)

They also measured the inter arterial distances between

Aortic bifurcation to celiac trunk	=	13.3 cm
Superior mesenteric artery to Inferior mesenteric artery	=	7.8cm
Aortic bifurcation to inferior mesenteric artery	=	4.6cm

- **Anson and M'C vay in (1936)** reported in their article on "A study of 100 cadavers" about the mean vertebral level of, origin of unpaired visceral branches of abdominal aorta and its bifurcation and also inter arterial distances between its branches.
    - Mean vertebral level of celiac axis – first lumbar vertebra (L1)
    - Mean vertebral level of superior mesenteric artery- lower border of first lumbar vertebra (LL1)
    - Mean vertebral level of inferior mesenteric artery – Body of third lumbar vertebra (BL3)
    - Inter arterial distance between

      celiac axis to superior mesenteric artery -1-2cm

      Inferior mesenteric artery to Aortic bifurcation -4.2 cm

- **Cauldwell and Anson (1943)** studied the topographic relationships of visceral branches of abdominal aorta in 300 cadavers. They reported the mean vertebral level of origin of these arteries as
    - celiac axis – first lumbar vertebra (L1)

- Superior mesenteric artery – lower border of first lumbar vertebra (LL1)
- Inferior mesenteric artery – Body of third lumbar vertebra (BL3)
- Aortic bifurcation – lower border of fourth lumbar vertebra (LL4)

and inter arterial distances between

- Aortic bifurcation to celiac trunk = 12.9cm
- Celiac axis to superior mesenteric artery= 1cm (1-1.9cm range)
- Superior mesenteric artery to inferior mesenteric artery=6.95cm (3.5 – 10.8cm)
- Aortic bifurcation to inferior mesenteric artery=4.5cm

➢ **Feller wood burne (1960)** studied the variations in the origin of aortic branches in 100 cadavers.They studied about the mean vertebral level of origin of abdominal aortic branches,inter arterial distances from aortic bifurcation, variations in branching pattern, deviation of course of abdominal aorta. They reported the mean vertebral level of origin of branches as

- celiac axis – first lumbar vertebra (L1)
- superior mesenteric artery– lower border of first lumbar vertebra(LL1)
- inferior mesenteric artery- body of third lumbar vertebra (BL3)
- right and left renal arteries– second lumbar vertebra (L2)
- Aortic bifurcation – lower border of fourth lumbar vertebra (LL4)

and inter arterial distances reported as

- Aortic bifurcation to celiac trunk = 12.7cm
- Celiac axis to superior mesenteric artery = 1.6cm
- Aortic bifurcation to inferior mesenteric artery =4.2 cm

  - They reported the mean length of abdominal aorta as 13 cm.
  - In their studies 16% of accessory renal arteries were encountered.
  - Lateral deviations of abdominal aorta were noted in 41% among them in 24% it was deviated to left and in 17% to right.

➢ S.R. Satchidhanandam (1987) in his study of ventral branches of abdominal aorta reported

- The vertebral level of origin of celiac axis varies from intervertebral disc (IVD) between twelfth thoracic vertebra and first lumbar vertebra (T12-L1) to body of first lumbar vertebra (BLI) with mean level at body of first lumbar vertebra (BL1)
- The mean vertebral level of superior mesenteric artery was at the level of first lumbar vertebra (L1)
- The mean vertebral level of inferior mesenteric artery at-body of third lumbar vertebra (BL3) and
- Aortic bifurcation at – Body of forth lumbar vertebra (BL4)

He also reported the inter arterial distances between

- celiac axis to superior mesenteric artery =1.2cm (0.4-1.7 range)
- superior mesenteric artery to inferior mesenteric artery = 5.2-7.2cm
- inferior mesenteric artery to aortic bifurcation = 3.9cm(3-5cm)

- **Neil Pennington et al (2005)** in their study of anterior visceral branches of abdominal aorta and their relationships to the renal arteries reported about the mean vertebral level of

    - Celiac trunk – below the midpoint of twelfth thoracic vertebra (BT12)
    - Superior mesenteric artery-upper third of body of first lumbar vertebra(UL1)
    - Inferior mesenteric artery –lower third of body of third lumbar vertebra (LL3)
    - Right & left renal arteries – lower third of body of first lumbar vertebra (LL1) and right renal artery was proximal than left renal artery in 60% .
    - Aortic bifurcation – lower third of body of fourth lumbar vertebra (LL4).

He also reported the width of abdominal aorta from proximal to distal.

- At the level of celiac axis = 2.49 + 0.48cm
- At the level of superior mesenteric artery =2.44+0.42mm
- At the level of inferior mesenteric artery = 2.11+0.55cm.

According to **Neil Pennington et al**. the morphological variations of abdominal aorta are of more interest. Because the vessel geometry is determined the flow dynamics and it is also crucial in the vascular pathology like atherosclerosis. He also reported that the abdominal aorta diameter was diminished gradually from diaphragm to its bifurcation. Proximally the aorta provided the elastic recoil and distally it was acted as a conduit. So, the diminution in the diameter of abdominal aorta from proximal to distal was being attributed to decrease in the flow volume of blood as it was supplied to the viscerals.

- **Songur et al (2010)** in his study of morphometric variations of abdominal aorta and its branches in 95 abdominal aorta autopsy cases reported the mean vertebral level of,
  - Celiac axis – intervertebral disc between twelfth thoracic vertebra and first lumbar vertebra (IVD T12-L1)
  - Superior mesenteric artery- intervertebral disc between first lumbar vertebra and second lumbar vertebra (IVDL1-L2)
  - Aortic bifurcation – lower border of fourth lumbar vertebra (L)
  - Both renal arteries – second lumbar vertebra (L2)

Inter arterial distances between

- Celiac axis to Superior mesenteric artery =1.4+0.26cm
- Superior mesenteric artery to inferior mesenteric artery = 5.7-8cm
- Inferior mesenteric artery to aortic bifurcation = 3.5 cm

They observed 16.8% multiple renal arteries 1% single gonadal artery.

- **Prakash et al 2011** in his cadaveric study in 50 cadavers about verterbral level of origin of important branches of abdominal aorta. He reported the mean vertebral level of
  - Celiac axis – at twelfth thoracic vertebra (T12)
  - Superior mesenteric artery – at first lumbar vertebra (L1)
  - Inferior mesenteric artery – at third lumbar vertebra (L3)
  - Both renal arteries – at first lumbar vertebra (L1)
  - Aortic bifurcation – at fourth lumbar vertebra (L4).

He also reported the higher level of origin of inferior mesenteric artery at second lumbar vertebra (L2) and higher bifurcating level of abdominal aorta at third lumbar vertebra (L3).

- **Chithiriki et al (2002)** in their MRI study of anatomical relationships of aortic bifurcation to lumbar vertebra reported, the position of aortic bifurcation was at the level of fourth lumbar vertebra (LL4) in 67-83% and among these in 24% it was at the level of middle third of body of fourth lumbar vertebra (BL4).

- **Lakchayapakorn (2008)** reported in their study of anatomical variations of position of aortic bifurcation to lumbar vertebra.He reported that the aortic bifurcation was between third lumbar vertebra to fifth lumbar vertebra .The aortic bifurcation was seen most often at the level of fourth lumbar vertebral body. In 63% the position of aortic bifurcation was at the level of fourth lumbar body (BL4) and in 57% at its middle third .The anatomical variations of level of aortic bifurcation in front of lumbar vertebra is important to vertebral surgeon.Because they can disturb the surgical exploration of lumbar vertebra and cause vascular injury to these vessels.

- Vertebral level of origin of unpaired ventral branches, renal arteries, aortic bifurcation by various studies were summarized and reported in the following table.

S.NO	STUDIES	CA	SMA	IMA	RRA	LRA	AB
1	**Ansons M'c vay (1936)**	L1	LLI	BL3	-	-	LL4
2	**Cauldwell & Anson (1943)**	L1	LLI	BL3	-	-	LL4
3	**George (1935)**	L1	LLI	BL3	-	-	LL4
4	**Feller (1965)**	L1	LLI	BL3	L2	L2	LL4
5	**S.R.S M.M.C(1987)**	L1	BL1	BL3	-	-	BL4
6	**N.Pennigton et al (2005)**	T1-4	UL1	LL3	LL1	LL1	LL4
7	**Songur et al (2010)**	T12-L1	L1-L2	L3	L2	L2	LL4
8	**Prakash et al (2011)**	T12	L1	L3	L1	L1	L4
9	**Chithiriki et al (2002)**						L4
10	**Lakchayapakron (2008)**						L4

(L1-1st Lumbar vertebra, T12- 12thThoracic vertebra, BLI - Body of 1st lumbar vertebra , LL1-Lower border of 1st Lumbar vertebra T12-L1 intervertebral disc between 12th thoracic and 1st lumbar vertebra; L2-2nd lumbar vertebra, L3-3rd lumbar vertebra; BL3- Body of 3rd lumbar vertebra; LL3- lower border of 3rd lumbar vertebra; L4-4th

lumbar vertebra; BL4- Body of 4th lumbar vertebra; LL4 – lower borders of 4th lumbar vertebra.)

- **Basmajian (1980) Maingot (1980) Morris (1953) Wood Jones (1953), Hollinshead (1966), Gray (40th edition 2008), Last (1984), E. Jamison (1986), G.J.Romanes (2009, 16th edition)** Text books of Human Anatomy describe the vertebral level of origin of branches of abdominal aorta and its bifurcation. These are shown in the following table

Name Of branches	Celiac Axis	Superior Mesenteric artery	Inferior Mesenteric Artery	Right Renal Artery	Left Renal Artery	Aortic Bifurcation
Vertebral level	T12-L1	L1	LL3	UL2	UL2	BL4

(T12- L1 intervertebral disc between 12th thoracic & 1st lumbar vertebra; L1-1st Lumbar vertebra;; UL2-upper border of 2nd lumbar vertebra; LL3-lower border of 3rd lumbar vertebra; BL4-Body of 4th lumbar vertebra.)

According to various text books of Human anatomy, Morris human anatomy (1953), Hollinshead (1966), Wood Jones (1953), Maingot (1980), Basmajian (1980), E.Jamison (1986) Last RJ (1984), Gray 40th edition. (2008), G.J.Roamnes (2009) 16th edition.

The abdominal aorta enters the abdomen by passing behind the aortic hiatus at the level of lower border of twelfth thoracic vertebra.

- Celiac axis at the level of inter vertebral disc between twelfth thoracic and first lumbar vertebra just below aortic hiatus.
- Superior mesenteric artery at the level of first lumbar vertebra.
- Inferior mesenteric artery at the level of lower border of third lumbar vertebra.
- The vertebral level of renal arteries just below the superior mesenteric artery at the interval between first lumbar vertebra to upper border of second lumbar vertebra. The right renal artery is little proximal than left one.
- The vertebral level of gonadal arteries described as just below the renal arteries at the level of second lumbar vertebra.

- The inter arterial distances of aortic branches are rarely reported by text books.
    - According to G.J. Roamnes (2009) the inter arterial distance between celiac axis and superior mesenteric artery is 1cm.
    - The distance between aortic bifurcation to inferior mesenteric artery origin is 3.75cm.
    - According to R.J. Last (1960) the inter arterial distance between celiac axis to superior mesenteric artery is 1.25cm.
    - According to Gray (2008) 40th edition. The inter arterial distance between celiac axis to superior mesenteric artery is 1cm and distance between aortic bifurcation to inferior mesenteric artery is 3.4cm.
    - According to Morries (1953) the inter arterial distance between celiac axis to superior mesenteric artery is range from 1cm – 2.2cm and the distance between aortic bifurcation to inferior mesenteric artery is 3.7cm.
    - According to Wood Jones (1960) the inter arterial distance between celiac axis and superior mesenteric artery is 0.6cm

and the distance between aortic bifurcation to inferior mesenteric artery is 3.75cm

- According to **Neil Pennigton et al** (2005) the width of abdominal aorta from proximal to distal was
  - at the level of celiac Axis = 2.49 cm ± 0.48,
  - at the level of superior mesenteric artery = 2.44 ± 0.42 mm and
  - at the level of inferior mesenteric artery = 2.11 ± 0.55 cm
- **Hasan et al (1994)** by ultrasonagraphic study in Saudi people – reported the aortic diameter
  - supra renal at the level of celiac axis = 1.99 ± 0.36 cm;
  - mid aortic diameter = 1.91 ±0.45cm and
  - just above bifurcation = 1.52±0.59
  - the average mean of 3 measurement as 1.8± 0.2 cm.

- **K.Adachi et al (2000)** in thier ultrasonagraphic study of abdominal aortic diameter in a screening programme in Japanesh population reported the aortic diameter as 1.72 ± 0.2 cm.

- **M.E. Lucarothi et al (1991)** – in thier ultrasonagraphic study of abdominal aortic diameter in a screening programme in European population reported the mean aortic diameter = 2.1 ± (0.55cm).

- **Dr. J.I. Spark et al (2001)** reported in epidemiological study of abdominal aortic aneurysm reported that the Caucasian population had larger aortic diameter than Asian population. The Caucasian population more prone for abdominal aortic aneurysm than Asian population.

- According to **James E. Crouch (1970)** in his Functional Human Anatony (Text book) the abdominal aorta gradually diminishes in size until its inferior portion is about 1.75 cm in diameter.

- According to **Gray's Anatomy 40th Edition (2008)** the cadaveric superior and inferior calipers are between 9-14 mm (0.9-1.4 cm) and 8-12mm (0.8-1.2cm) respectively.

- According to **Wood Burne (1966)** the length of abdominal aorta reported as 13cm and **Keith Moore (2010)** described the length of abdominal aorta as 13cm, **Wood Jones (1960)** describes the length as 5 inches and **A.K. Dutta** in his essentials of Human Anatomy describes the length of abdominal aorta as 10-11 cm and its breadth as 2 cm.
- Inter arterial distance between celiac axis and superior mesenteric artery, between superior mesenteric artery and inferior mesenteric artery and between inferior mesenteric artery and aortic bifurcation were noted by various studies. They are also reported by text books of Human anatomy . They have been summarized in the following table.
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	INTER ARTERIAL DISTANCE				
S.NO	**STUDIES**	**CA-SMA**	**SMA-IMA**	**IMA-AB**	**AB-CA**
1	**G.J.Romanes (T.B – 16th edition 2009)**	1 cm		3.75 cm	
2	**Last (TB) (1987)**	1.25 cm		-	

3	Gray (TB) (40th edition 2008)	1cm		3.4cm	
4	Morries (T.B) (1953)	1-22 cm		3.7cm	
5	Wood Jones (T.B) (1960)	0.6cm		3.75cm	
6	Anson & M'cvay (1936)	1-2 cm		4.2cm	
7	Could well & Anson (1943)	1-1.9cm	6.95 cm	4.5cm	1.9cm
8	George (1935)	-	7-8cm	4.6cm	13.3cm
9	Wood burne (1966)	1.6cm	-	4.2cm	12.7cm
10	SRS MMC (1987)	0.4-1.7 cm	5.2-7.2cm	3.5cm	-
11	Songur et al (2010)	1.4 ± 0.26 cm	5.7-8cm	3.5cm	10.7±1.5cm

(CA- Celiac Axis; SMA – Superior mesenteric artery; IMA – Inferior messianic artery; AB- Aortic bifurcation)

Review of Literature – for variations in branching pattern

- **K.Adachi et al (1928), Morris (1953), Michels (1955) , Meschen (1968), Hollinshead (1966) Gray (40th edi 2008) S.R.Satchidhanandam (1987)** reported common origin of

celiac axis and superior mesenteric artery as common celiaco mesenteric trunk.

- According to **Michels (1955)** origin of celiac artery and superior mesenteric artery as a common trunk from abdominal aorta was rare and it was about less than 1%.

- According to **Dunbar (1965)** the celiac artery will be compressed by median arcute ligament when it was originated at a higher level.

- **Banowsky (1989), Singh G et al (1998) Bordei et al (2004), Raikos et al (2010) , Satyapal et al (2001)** stated that unilateral accessory renal arteries are more common on the left side (30-35%) with an additional 10% have bilateral renal arteries.

- Raikos et al reported unilateral accessory renal artery on the left side in their cadaveric study.

- **Notkovich H.C (1956)** reported the renal origin of gonadal arteries in 14%. They found that gonadal arteries may arise from the principal renal artery ,or from its branches,or from an accessory renal artery.

- **Singh G et al (1998), Sarita Sylvia et al (2009), Sonis, Wadhwa.A et al (2010)** reported bilateral renal accessory arteries with variant origin of gonadal arteries from renal arteries.

- **Singh G et al** reported accessory renal arteries with origin of both gonadal arteries from their respective accessory renal arteries.

- **Sylvia et al** reported double renal arteries, with variant origin of testicular arteries from renal arteries, on both sides. Right testicular artery took origin from right superior renal artery. Left testicular artery took origin from left inferior renal artery.

- ***Cicekcibasi AE et al.*** *(2005) reported a bilateral accessory inferior polar artery variation of 10.5 % in their study on 90 foetuses.*

- ***Cicekcibasi AE et al.*** *(2002) reported that in 5.5% the gonadal arteries were arised from renal artery*

- **Panyanetinad et al (2010)** reported bilateral lower renal accessory arteries. They also reported variant origin of gonadal

artery from renal arteries. Right testicular artery along with right inferior supra renal artery took origin from common trunk. This common trunk took origin from right renal artery proper.

- **Notkovich. H (1956), Naito et al (2006) Bandopadhyay et al (2009)** reported in a study of 183 cadavers that left gonadal arteries arched over the left renal vein in 20.3%. Arching of left renal vein by left gonadal artery was also reported by Notkovich .H in 6.7%.*)*

- **Notkovich. H (1956),** divided the testicular artery pattern into three types.

    - Type 1: After its origin from aorta testicular artery runs downwards without any contact with renal vein.
    - Type 2: Testicular artery originated at a higher level than the renal vein.
    - Type 3: Testicular artery originated at a lower level than the renal vein and then arches over the vein to descend.

- **Pick JW, Anson BJ (1940), Piao et al (1998) Loukas et al (2005) Gokan et al (2001) GownDI et al (2007) Gray's**

Anatomy (40th edition 2008) reported about the origin of the inferior phrenic arteries from aorta and celiac trunk to be the most common sources. They also reported origin of inferior phrenic arteries from renal artery. They found that most frequent origin from the aorta and celiac trunk (45.1%and47.8%). They also observed the right inferior phrenic arteries arising from right renal artery in 9%.The precise localization of inferior phrenic artery is significant during hepatic surgery.

- **Bakheit et al (2004) Deepthinath. R et al (2006)** reported the origin of inferior phrenic artery from renal artery.
- **Deepthinath. R.et al (2006)** also reported the origin of right middle supra renal arteries from right renal artery.
- **Siniluto et al (1988), Riddell et al (2004)** reported testicular infarction following ethanol embolization of a renal neoplasm and left adrenal infarction. Impaired blood transfusion to supra renal gland leading to ischemia.
- **Naito et al and skoog et al (1997) Lellie et al (2007)** reported looping of left testicular artery might lead to compression of left

renal vein and may precipitate engorgment of left testicular vein leading to varicocele. According to Lellie [12] arching of testicular artery over the left renal vein might be an additional cause of Nutcracker syndrome as well as renal hypertension.

- **Schellammer.F et al (1997)** reported that [22] kinking of abdominal aorta is also known as pseudo coarctation or buckling of aorta.
- **Satheesh Nayak et al (2008)** reported [22] a kink in the abdominal aorta above the level of origin of renal arteries.

MATERIALS AND METHODS

Materials

Stainless steel students scalpel

Stainless steel forceps - toothed and non toothed.

Stainless steel long and short straight scissors

Knife and bone cutter

Rubber sheet, H.B. pencil, Orange Cream sheet, 0.4 mm thread and cotton

Gloves and Apron

Digital vernier caliper

Covered container for preserving specimens in formalin

10% formalin

20 ml syringe

Canon Digital camera (10 mega pixels)

Methods

The study was conducted in Institute of Anatomy, Madurai Medical College, Madurai .

Sample Study (Collections of sample)

The study was done in 50 human cadaveric specimens irrespective of age and sex. The specimen were obtained from cadavers allotted for dissection in the Institute of Anatomy. Madurai Medical College, Madurai and postmortem specimens from the Deportment Of Forensic Medicine, Madurai Medical College, Madurai . The specimens were numbered serially from 1-50 and readings were recorded and tabulated. Possible variations of abdominal aorta and its branches were noted and photographed.

Method of Study

Manual dissection was done in according to the text book of cunningham's manual of practical anatomy (16^{th} edition 2009) Abdominal cavity was opened by cutting and reflecting the anterior abdominal wall muscles. Abdominal visceras were mobilized to expose the origin of important branches of abdominal aorta. After the removal

of the abdominal viscera the diaphragmatic curare and arcuate ligaments were exposed to see the aortic hiatus through which the abdominal aorta enters the abdomen by passing behind to it.

Origin of celiac trunk, superior mesenteric artery, inferior mesenteric artery, right and left renal arteries, right and left gonadal arteries , inferior phrenic arteries, lumbar arteries and bifurcation of abdominal aorta were noted.

The vertebral level of origin of celiac trunk superior mesenteric artery, inferior mesenteric artery, renal arteries , aortic bifurcation were noted and recorded.

The length of abdominal aorta was measured by measuring the distance between Aortic bifurcation to origin of inferior phernic arteries which is the first branch of abdominal aorta very close to aortic hiatus. If the inferior phrenic arteries arised from other sources than abdominal aorta 0.5cm was added to the distance between aortic bifurcation to celiac trunk. Because the distance between inferior phrenic arteries to celiac trunk was about 0.5 cm.

The External diameter of abdominal aorta measured from its outer wall to outer wall in horizontal direction at the three levels one at the level of celiac artery as supra renal aortic diameter and another at the level just below the renal arteries as mid aortic diameter and third one at the level just above aortic bifurcation.

The mean of all the three diameter were calculated and observed as aortic diameter.

The inter arterial distance between origin of celiac axis to superior mesenteric artery and superior mesenteric artery to inferior mesenteric artery and inferior mesenteric artery to aortic bifurcation were measured

All these measurements length, external diameter of abdominal aorta at various levels and inter arterial distances were measured by digital vernier caliper.

The course of abdominal aorta weather it continued on a straight course or deviated to right or left side was noted and photographed.

Possible variations of branching of abdominal aorta were noted and photographed.

Post mortem specimens were collected from the Department of Forensic Medicine, Madurai Medical College, Madurai-20.

The abdominal aorta along with its ventral and lateral branches removed in toto. The specimens were washed in running water. Then 300 – 400 ml of 10% formalin was injected through one cut end of abdominal aorta using 20 ml syringe. Then the specimens were completely immersed in the buckets containing 10% formalin solution and were preserved for 10 days then studied.

OBSERVATION

By manual dissection of abdominal aorta in human specimens the following were observed.

VERTEBRAL LEVEL OF

a) Aortic hiatus

In all the 50 specimens the abdominal aorta entered the abdomen by passing behind the aortic hiatus at the level of lower border of twelfth (LT-12) thoracic vertebra.

b) Anterior visceral branches (unpaired)

Celiac axis (table-1)

- In 16 out of 50 specimens the origin of celiac axis was at the level of intervertebral disc between twelfth thoracic vertebra and first lumber vertebra. (IVD-T12-L1)
- In 15 out of 50 specimens the origin was at the level of upper border of first lumbar vertebra.(UL1)
- In 14 out of 50 specimens the origin was at the level of lower border of twelfth thoracic vertebra.(LT12)

- In 5 out 50 specimens the level of origin of celiac axis was opposite to body of first lumbar vertebra.(BL1)
- In one out 50 specimens the celiac artery was arised in common with superior mesenteric artery as common celiaco mesenteric trunk at the level of lower border of twelfth thoracic vertebra (LT12) (spc:32) (figure:1)

ii) Superior mesenteric Artery (table-1)

- In 21 out of 50 specimens the origin of superior mesenteric artery was at the level of upper border of first lumbar vertebra.(UL1)
- In 22 out of 50 specimen the origin was at the level of body of first lumbar vertebra.(BL1)
- In 5 out of 50 specimen the origin was at the level of lower border of first lumbar vertebra.(LL1)
- In one specimen the origin was at the level of intervertebral disc between twelfth thoracic and first lumbar vertebra.(IVD_T12-L1)

- In one specimen where celiac mesenteric trunk was present the origin was at the level of lower border of twelfth thoracic vertebra.(LT12)
- Totally in 48 specimens out of 50 the level of origin of superior mesenteric artery was first lumbar vertebra.(L1)

iii) Inferior Mesenteric artery (table-1)

- In 30 out of 50 specimens the origin of inferior mesenteric artery was at the level of lower border of third lumbar vertebra.(LL3)
- In 6 out of 50 specimens level was intervertebral disc between third lumbar and fourth lumbar vertebra.(IVD-L3-L4)
- In one out of 50 specimens it was at the level of body of second lumbar vertebra.(BL2) (sp-33) (figure:10).
- In one out of 50 specimens it was at the level of lower border of second lumbar vertebra.(LL2) (sp-44) (figure:4).
- In one specimen out of 50 the level of origin of inferior mesenteric artery was the intervertebral disc between second and third lumbar vertebra.(IVDL2-L3) (sp-5) (figure:11)

c) Paired lateral visceral branches

i) Renal arteries (table-1)

- In 39 out of 50 specimens the right renal artery was originated at the level of lower border of first lumbar vertebra.
- In 37 out of 50 specimens the left renal artery was originated at the level of lower border of first lumbar vertebra.
- In 10 out of 50 specimens on the left and 8 out of 50 specimens on the right renal arteries were arised at the level of upper border of second lumbar vertebra.
- In 2 out of 50 specimens on the right and 1 out of the 50 specimens on the left the level of origin of renal artery was intervertebral disc between first and second lumbar vertebra.
- In 30 out of 50 specimens the right renal artery was proximal to left one.
- In 9 out of 50 specimens the left renal artery was proximal to right one and in 8 cases both arteries are at same level.

- In 3 out of 50 specimens accessory renal arteries were present. .(figure:2,3&4)

- In specimen no 18 the accessory renal arteries present on both sides. Both the main renal artery and accessory artery of both sides arised from lateral aspect of abdominal aorta at the level of first lumbar vertebra. (figure:3)

- In specimen no 22 the accessory renal artery was present on the left side at the level of upper border of second lumbar vertebra. (figure:2) The main renal artery was present at the level of body of first lumbar vertebra. On the right side the renal artery was single at the level of lower border of first lumbar vertebra.

- In specimen 44 bilateral accessory renal arteries were present (figure:4).

- On the right side the upper right renal artery was originated from lateral aspect of abdominal aorta just above the superior mesenteric artery.The lower right renal artery was originated at the level of superior mesenteric artery. On the left side upper left renal artery was

originated from the lateral aspect of aorta at the level of superior mesenteric artery.The lower left renal artery was originated just below the the upper left renal artery.

ii) Gonadal Arteries (table-1)

- In 47 out of 50 specimens the right and left gonadal arteries were arised from second lumbar vertebra at same level.
- In one out of 50 specimens there were variant origin of gonadal arteries from renal arteries instead of abdominal aorta. Their vertebral level corresponding to level of renal arteries. (figure:5)
- In specimen 45 the right gonadal artery was arised at the level of lower border of second lumbar vertebra and on the left side the level of origin was just below the renal artery and it arched over the left renal vein at the level of lower border of first lumbar vertebra (figure:6).

d. Aortic Bifurcation (table-1)

- In 31 out of 50 specimen the abdominal aorta was bifurcated at the level of body of fourth lumbar vertebra.
- In 9 out of 50 specimens the level of bifurcation was upper border of fourth lumbar vertebra.
- In 8out of 50 specimens the level of bifurcation was lower border of fourth lumbar vertebra.
- In one out of 50 specimens the aorta bifurcated at the level of intervertebral disc between fourth and fifth lumbar vertebra. (figure:1)
- In one out of 50 specimen the level of bifurcation was lower border of third lumbar vertebra. (figure:10)

II. According to length of Abdominal Aorta (table-2)

- The length of abdominal aorta in 50 specimen were ranged between 10.4 cm to 13.1 cm.
- In 9 out of 50 specimens the length of abdominal aorta was ranged between 10.4 to 10.9 cm.

- In 25 out of 50 specimens the length of abdominal aorta was 11-11.9cm.
- In 16 out of 50 specimens the length of abdominal aorta was ranged between 12cm – 13.1 cm
- .And the maximum frequency occurred between 11-11.9 cm.

III. Width of Abdominal Aorta (table -3):

Width of abdominal aorta was measured at three levels:

- one at the level of celiac trunk,
- one at the level of just below the renal arteries and
- one at the level of just above its bifurcation.

At the level of celiac trunk : (Suprarenal aortic diameter)

- In 9 out of 50 specimens the supra renal aortic diameter was ranged between 1.52 cm – 1.69 cm.
- In 15 out of 50 specimens it was about 1.7cm to 1.79 cm and in 22 out of 50 specimens it was about 1.82 cm to 1.98 cm.

- In 4 out of 50 specimens the supra renal aortic diameter was 2.12 to2.31 cm.
- The maximum frequency occurred between 1.7 cm to 1.98 cm.

Mid Aortic Diameter : (Just below renal artery)

- In 15 out of the 50 specimens, the mid aortic diameter was 1.5 cm to 1.6 cm.
- In 12 out of 50 specimens, it was 1.61cm to 1.69cm.
- In 7 out of 50 specimens, it was 1.71 cm to1.79cm.
- In 11 out of 50 specimens, it was 1.8 to1.88 cm and in 4 specimens the mid aortic diameter was 1.99 to 1.99 cm.
- In one specimen, it was about 1.38 cm.
- The maximum frequency occurred between 1.5 cm to 1.88 cm.

Just above its bifurcation

In 18 specimens out of 50 specimens, the aortic diameter just above its bifurcation was 1.3cm to 1.39 cm.

In 27 specimens out of 50 specimens, the aortic diameter just above its bifurcation was 1.4 cm to 1.49cm

In 4 out of 50 specimens, the aortic diameter just above its bifurcation was 1.52 cm to1.83cm.

The maximum frequency occurred between 1.4 cm to 1.49cm.

IV. Inter Arterial Distance (table 4)

Distance between Celiac axis to superior mesenteric artery:

- In 13 out of 50 specimens the distance between celiac axis to superior mesenteric artery was ranged between 0.6 cm to 0.9 cm .
- In 36 out of 50 specimens the distance between celic axis to superior mesenteric artery was about 1 to 1.7cm .
- Maximum frequency occurred in 1.2 cm.
- In one specimen the common celiaco mesenteric trunk was present.

Distance between Superior Mesenteric Artery to Inferior Mesenteric Artery:

- In 21 out of 50 specimens the distance between superior mesenteric artery to inferior mesenteric artery was 5.2 cm to 5.9cm .
- In 26 out of 50 specimens the distance was 6cm to 6.9 cm and in 3 specimens it was about 7cm to 8.4 cm.
- The maximum frequency occurred between 6 cm – 6.9 cm.

Distance between Inferior Mesenteric Artery to Aortic Bifurcation:

- In 32 out of 50 specimens the distance between inferior mesenteric artery to aortic bifurcation was 3.2cm to 3.9 cm.
- In 18out of 50 specimens it was about 4.1 cm 4.7 cm
- .The maximum frequency occurred at 3.8cm.

V. Course of Aorta

- In 46 out of 50 specimens the abdominal aorta continued on a straight course from diaphragm to its bifurcation.
- In 2 specimens (2,18) the abdominal aorta showed a slight right side deviation. (figure:12&13)
- In one specimen (5) the abdominal aorta more deviated to left margins of lumbar vertebrae (figure:11)
- In one specimen (44) the abdominal aorta showed a dilatation at the level of inferior mesenteric artery and convexity towards left from that level to its bifurcation. (figure:5)
- In 2 specimens out of the 50 (33,5) the abdominal the abdominal aorta showed a kinking at the level of origin of renal artery (5) and at the level of inferior mesenteric artery . (figure:10&11)

IV Variations in Branching Pattern

- Out of 50 specimen in one specimen common celiaco mesenteric trunk was seen. (figure:14) In one specimen (32)common celiaco mesenteric trunk was arised from the ventral aspect of aorta at the level of aortic hiatus.

- Out of 50 specimen in 3 specimen accessory renal arteries were present. In 2 bilateral accessory arteries were seen. In one specimen unilateral accessory artery on the left side was seen.(figure:15,16&17)

  - In specimen(44)(figure:16) two renal arteries were seen bilaterally. On the right side upper renal artery(RURA) was arised from the lateral aspect of abdominal aorta just above the superior mesenteric artery at the level of intervertebral disc between twelfth thoracic and first lumbar vertebra.Lower renal artery (RLRA) was arised from the lrteral aspect of abdominal aorta at level of super mesenteric artery.

    On the left side upper renal artery (LURA)was arised from the lateral aspect of aorta just below the superior mesenteric

artery.Lower renal artery (LLRA) was arised 0.5 cm below the upper renal artery.

- In another specimen(18)(figure:15) bilateral renal accessory arteries were arised from the ventro lateral aspect of abdominal aorta just below the superior mesenteric artery at the level of upper border of first lumbar vertebra.

- In specimen (22) (figure:17) unilateral accessory renal artery was present on the left side. The upper renal artery (ULRA) took origin from the lateral aspect abdominal aorta just below the superior mesenteric artery at the level of body of first lumbar vertebra. The lower renal artery (LLRA) took origin from the lateral aspect of abdominal aorta 2.7 cm below the upper renal artery at the level of lower border of second lumbar vertebra.

- In one out of 50 specimens variant origin of gonadal arteries from renal arteries were seen.

    - In specimen no 44 both right and left gonadal arteries were arised from renal arteries.Both sides they were arised from upper renal arteries (figure:18)

- According to inferior phrenic arteries in 30 out of 50 specimens the origin of inferior phrenic artery took origin from the abdominal aorta. Among the 30 specimens in 14 was present as separate branches and in 16 as common trunk .

In 18 out of 50 specimens the inferior phrenic arteries originated from celiac trunk. Among them in 8 specimens as separate branches and in 10 as common trunk.

In one specimen on the right side the inferior phrenic artery took origin from renal artery as a common trunk along with middle supra renal artery. On the left side it took origin from celiac trunk (figure:19).

In one specimen the inferior phrenic artery took origin from celiac trunk on the right side. On the left side it took origin from aorta.

According to middle supra renal artery in 49 out of 50 specimens paired vessels arising from the aorta opposite to the origin of superior mesenteric artery.

In one specimen (45) supra renal arteries from both sides took origin from renal arteries (figure: 19).

- According to lumbar arteries in all the 50 specimens 4 lumbar pairs were present.
- According to median sacral artery in all the 50 specimens it was arised from dorsal aspect of abdominal aorta few mm above its bifurcation.

DISCUSSION

The study of morphology of abdominal aorta in 50 specimens were compared with previous studies.

According to Grays anatomy 40th edition the abdominal aorta enters the abdomen, by passing behind the median aortic hiatus of diaphragm , anterior to lower border of twelfth thoracic vertebra and thoracolumbar intervertebral disc.

It descends infront of the lumbar vertebrae and end at the lower border of the fourth lumbar vertebra a little to the left of mid line by dividing into two common iliac arteries.

It diminishes rapidly in caliber from above downwards because its branches are large.

The branches of abdominal aorta can be classified as single visceral, double visceral, double parietal, single parietal, terminal for the supply of all the derivatives of gastro intestinal tract , gentiourinary tract, roof and walls of abdomen , pelvic cavity and its organs and lower limbs.

Single visceral branches – Celiac artery, superior mesenteric artery, inferior mesenteric artery

Double visceral branches – Renal arteries, gonadal arteries, Middle supra renal arteries.

Double parietal – Inferior phrenic Arteries, lumbar arteries.

Single parietal- Median sacral artery.

Terminal - Common iliac arteries

I. VERTEBRAL LEVEL OF

a. Aortic Hiatus

G.J. Romanes (16th edition 2009), Gray's (40th edition 2008) Basmajian (1980) Last (1984) Wood Jones (1953) text books of anatomy describe that the abdominal aorta enters the abdomen by passing behind aortic hiatus at the level of lower border of 12th thoracic vertebra.

According to Cauld well and Anson (1943) the aorta may pass through the esophageal hiatus.

In the present study in all the 50 specimens the abdominal aorta entered the abdomen by passing behind the median aortic hiatus at the level of lower border of twelfth thoracic vertebra. No variations were seen.

b. Vertebral level of unpaired & paired visceral branches:

Unpaired and paired visceral branches of abdominal aorta includes – celiac axis, superior mesenteric artery, inferior mesenteric artery as unpaired visceral branches – supply the derivatives of gastro intestinal tract and renal arteries and gonadal arteries as paired visceral branches supply the derivatives of genito- urinal system. (Kidney, gonads)

The text books of anatomy Wood Jones (1953) Moories (1953), Wood burne (1966), Gardner Gray O' Rahilly (1978), Hollinshead (1966), Basmajian T.V (1980) Maingot (1980), Last R.J.(1984), G. J Roamnes (2009), Gray's Anatomy (2008) Keithmoore (2010) describe the level of origin of all their branches as:

Celiac axis at the level of intervertebral disc between twelfth thoracic and first lumbar vertebre(IVD T12-L1) just below the aortic hiatus, and superior mesenteric artery at the level of first lumbar (L1) vertebra just below celiac axis and inferior mesenteric artery at the level of lower border of third lumbar vertebra. (L3)

They describe the vertebral level of renal arteries just below the superior mesenteric artery at the level of first lumbar (L1) and upper border of second lumbar vertebra. The right renal artery is little higher than left renal artery. Gonadal arteries at the level of second lumbar vertebra just below the renal arteries.

Various studies done by Anson & M'c vay (1936), Cauld well & Anson (1943) George (1935) Feller Wood burne (1966) S.R. Satchidhanadam (SRSMMC) (1987) N.Pennington et al (2005) Songur et al (2010) , Prakash et al (2011) reported maximum frequency of the level of origin of all these branches.

. Vertebral level of origin of branches abdominal aorta by various studies shown below.

S. No	STUDIES	VERTEBRAL LEVEL OF BRANCHES						
		CA	SMA	IMA	RRA	LRA	RGA	LGA
1	Ansons M'c vay (1936)	L1	LLI	BL3	-	-	LL4	
2	Cauldwell & Anson (1943)	L1	LLI	L3	-	-	LL4	
3	George (1935)	L1	LLI	L3	-	-	LL4	
4	Feller (1965)	L1	LLI	L3	L2	L2	LL4	
5	SRSMMC (1987)	L1	BL1	BL3	-	-	BL4	
6	N.Pennigton et al (2005)	T12-L1 (IVD)	L1	LL3	L1	L1	-	
7	Songur et al (2010)	T12-L1 (IVD)	L1-L2 (IVD)	L3	Below SMA	Below SMA	Below RA	Below RA
8	Prakash et al (2011)	T12	L1	L3	L1	L1	L2	L2

In the present study the level of origin of all these unpaired and paired visceral branches reported below.

BRANCHES	VERTEBRAL LEVEL							
	T12	**T12-L1**	**L1**	**L1-L2**	**L2**	**L2-L3**	**L3**	**L3-L4**
CA	28%	32%	40%	-	-	-	-	-
SMA	2%	2%	96%	-	-	-	-	-
IMA	-	-	-	-	4%	2%	72%	22%
RRA	-	-	78%	4%	16%	-	-	-
LRA	-	-	74%	2%	20%	-	-	-
RGA	-	-	-	-	88%	-	-	-
LGA	-	-	4%	-	84%	-	-	-

(L1-1st Lumbar vertebra, T12- 12thThoracic vertebra, BLI - Body of 1st lumbar vertebra , LL1-Lower border of 1st Lumbar vertebra T12-L1 intervertebral disc between 12th thoracic and 1st lumbar vertebra; L2-2nd lumbar vertebra, L3-3rd lumbar vertebra; BL3- Body of 3rd lumbar vertebra; LL3- lower border of 3rd lumbar vertebra; L4-4th lumbar vertebra; BL4- Body of 4th lumbar vertebra; LL4 – lower borders of 4th lumbar vertebra.)

Celiac Axis

According to Cauld well & Anson (1943) the level of celiac artery origian is inconsistent. In 85% the celiac artery arise from lower third of twelfth thoracic vertebra to middle third of first lumbar vertebra .The most frequent origin is out the level of upper third of first lumbar vertebra.

According to Dunbar (1965) higher level of origin of celiac artery often associated with entrapment syndrome. Lipshutz (1917) discussed relation of aortic hiatus to the origin of celiac artery. He observed that in 8 out of 56 dissections the celiac artery was covered by diaphragm.

According to him the basis for the entrapped artery was appeared to be high origin with the resultant compression as it passes through the aortic hiatus or an abnormally low crossing of median arcuate ligament with the normally located artery.

The maximum frequency of vertebral level of origin of celiac axis in the present study was at first lumbar vertebra(L1) in 40%, and then at inter vertebral disc between twelfth thoracic and first lumbar vertebra (IVD T12-LL1) in 32% and then at lower border of twelfth thoracic vertebra(LT12) in 28%, (Table:1) (chart:1).

This study was very well coincided with Ansn M'c Vay (1936), George (1935), Cauld well & Anson (1945), Feller Wood Burne (1966), SR.Satchidanandam MMC (1987) who reported the maximum frequency of origin at the level of first lumbar vertebra(L1), N. Pennington et al (2005) and Songur et al (2010) reported maximum frequency at the level of intervertebral disc between twelfth thoracic and first lumbar vertebra(IVD T12-L1) and Prakash et al (2011) reported maximum frequency at the level of twelfth thoracic vertebra (T12) and then in 36% at first lumbar vertebra(L1). The origin of celiac axis in relation to aortic hiatus gains importance since the celiac trunk can be compressed by arcuate ligament of diaphragm (Jamison).

Superior Mesenteric Artery

In the present study maximum frequency of level of origin of superior mesenteric artery was at the level of first lumbar vertebra(L1) in 96%(Table:1) (chart:2). This study was very closed to study of Cauld well & Anson (1943), George (1935), Heidsieck (1928), S.R.SatchidhanandamMMC (1987) , Wood Jones (1953) Wood Burne (1966) Hollinshead (1966), Basmajian (1980)R.J.Last (1984),

G.J.. Romanes(2009), Gray's Anatomy (2008), N. Pennington et al (2005) Prakash et al (2011).

In 2 % the level of origin was reported in inter vertebral disc between twelfth thoracic and first lumbar vertebra (IVD T12-L1). In one specimen the level was lower border of twelfth thoracic vertebra(LT12) where celiaco mesenteric trunk was seen . These levels of origin were reported by Cauld well & Anson (1936) .

Inferior Mesenteric Artery

In the present study maximum frequency of origin of inferior mesenteric artery was at the level of third lumbar vertebra(L3) 72% (Table:1) (chart:3).

This study was very well closed to Anson M'c vay (1936), George (1935) could well & Anson (1943), Feller Wood burne (1966), S.R.SatchidhanandamMMC (1987) N. Pennington et al (2005) Songur et al (2010) Prakash et al (2011) and also to description of text books.

In 4% of specimens higher level of origin of inferior mesenteric artery at the level of second lumbar vertebra(L2) & intervertebral disc

between second lumbar third lumbar vertebra(IVD L2-L3) were present. These levels were reported by Cauld Well & Anson (1945).

In 22% the level of origin was at inter vertebral disc between third lumbar and fourth lumbar vertebra (IVD L3-L4). This level was reported by S.R.Satchidhanandam MMC (1987) & Prakash et al (2011).

Renal Arteries

In the present study maximum frequency of origin of renal arteries were at the level of lower border of first lumbar vertebra. It was about 78% on the right side , and 74 % on the left side (Table:1) (chart:4&5).

This study was very well coincided with study of N. Pennington et all (2006), Prakash et al (2011)

In 60% specimen the right renal artery was proximal to left renal artery and 16% both renal arteries were originated at same level. This study was very close to N .Pennington et al (2006).

Gonadal Arteries:

In the present study Gonadal arteries were originated at the level of second lumbar vertebra (L2) with maximum frequency. (94% both sides).

This study was very close to Prakash et al (2011).

In 2 specimen left gonadal arteries were originated at higher level than right gonadal arteries and in one specimen the left gonadal artery arched over the left renal vein. This type of pattern was reported by Notkovich.H (1956), Naito et al (2006) Bandopathyay et al (2009).

Vertebral level of Aortic Bifurcation

According to G.J. Romanes (2009 16th edition) Gray (40th edition 2008), Basmajian (1980) Last (1984) Wood Jones (1953) text books of anatomy describe that the abdominal aorta bifurcates at the level of body of fourth lumbar vertebra (BL4)

Cauld well & Anson (1943) reported that the level of bifurcation ranged between the middle of third lumbar to lower third of fourth lumbar vertebra with mean level of bifurcation was at the

lower edge of fourth lumbar vertebra and in 28.2 % it occurred opposite to disc between fourth and fifth lumbar vertebra.

Adachi (1928) Heidsieck (1928) Taniguchi (1931) George (1935) (Total 511 cases) placed the bifurcation at the lower third of fourth lumbar vertebra.

Thane (1982), SSOSON (1926) S.R.SatchidhanandamMMC (1987) N.Pennington et al (2006) Lakchayapakorn et al (2008) Prakash et al (2011) reported the level of aortic bifurcation with maximum frequency at body of fourth lumbar vertebra.

S.R.Satchidhanandam MMC (1987), T.Sukamoto (1929) reported the level of bifurcation at intervertebral disc between fourth and fifth lumbar vertebra(IVD L4-L5) S.R.SatchidhanandamMMC (1987) reported the level at inter vertebral disc between third and fourth lumbar vertebra (IVD L3-L4) also.

In the present study the level of aortic bifurcation was at body of fourth lumbar vertebra (L4) in 62% (Table:1) (chart:6). This compared wall with studies of Thane (1892) SSOSON (1926), Adachic (1928), MC Murrich (1936) Cauld well & Anson (1943), Wood Jones (1953),

Romanes (2009), Grays's (2008), Last (1984) S.R.SatchidhanandamMMC (1987) Kajorn et al (2008) Prakash et al (2011).

In 16% the level was lower border of fourth lumbar vertebra(L4). This study was compared well with Adachi (1928), Heidsieck(1928), Taniguchi (1931) and George (1935).

In 18% the level was upper border of fourth lumbar vertebra (L4). This compared well with Cauld Well & Anson (1943), Prakash et al (2011).

In 2% the level was at lower border of third lumbar vertebra (LL3) which was similar to study of Cauld Well & Anson (1943) Prakash et al (2011).

In 2% the level was at disc between fourth and fifth lumbar vertebra(IVD L4-L5) . This compared well with Tsukamoto (1929), Cauld Well & Anson (1943), S.R.Satchidhanandam MMC (1987).

The high incidence of positional anatomical variations of aortic bifurcation to lumbar vertebra can disturb the surgical exploration of lumbar vertebra.

II. Length of Abdominal Aorta:

According to Wood Burne (1961) the inferior phrenic arteries mark the approximate level of the median arcuate ligament and the upper most limit of abdominal aorta. This upper limit is at the level of lower border of twelfth thoracic vertebra. By such criteria the aorta measures 13cm from its entrance into the abdomen to its aortic bifurcation.

According to Wood Jones (1953) the length of abdominal aorta is 5 inches.

According to Keith Moore (2010 6th edi) the length of abdominal aorta is approximately 13cm in length.

According to A.K. Datta in his essentials of human anatomy Part – 1 (2008-8th edition) the length of abdominal aorta was 10-11cm According to N. Pennigton et al (2006) the length of abdominal aorta was 16.6mm. Here they measured the length of abdominal aorta from midpoint of twelfth thoracic vertebra to aortic bifurcation.

In the present study the length of abdominal aorta was ranged from 10.4 to 13.1 cm. The maximum frequency occurred

between11cm-11.9cm. The mean length of abdominal aorta was 11cm which was very close to A.K.Dutta (Table:2) (chart:7).

III. Width of Abdominal Aorta

Gray's Anatomy (2008 40th edition) describes that the cadaveric superior and inferior calibers ranged between 0.9 to 1.4cm and 0.8 to 1.2cm. The diameter of aorta was decreased from proximal to distal.

N. Pennigton et al reported that the diameter at the level of celiac axis was 2.4 ± 0.48cm and at the level of superior mesenteric artery was 2.4 ±0.42 cm and at the level of inferior mesenteric artery was 2.1 ± 0.55cm

Cadaveric study of abdominal aorta diameter was rarely reported. In ultra sonagraphic studies by Hasan et al (1994) , Koichi et al (2000) they reported the mean aortic diameter. In their screening programme of abdominal aortic aneurysm in Saudhi population Hasan et al reported the mean diameter of abdominal aorta as 1.8 ±0.02 cm and in Japanesh population Adachi et al reported the mean diameter of abdominal aorta as 1.72 ± 0.22 cm.

M.E., Lucarotti et al (1991) in their screening programme for abdominal aortic aneurysm reported the mean aortic diameter as 2.1± 0.55 cm in European population.

Dr. J.I. Spark et al (2001) in British Journal of surgery reported the diameter of Abdominal Aorta in Asian population was smaller than Caucasian population and they also found prevalence of abdominal aortic aneurysm was higher in Caucasian population whose Abdominal aorta diameter was higher.

According to **Neil Pennington et al**. the morphological variations of abdominal aorta are of more interest. Because the vessel geometry is determined the flow dynamics and it is also crucial in the vascular pathology like atherosclerosis reported that the abdominal aorta diameter was diminished gradually from diaphragm to its bifurcation. Proximally the aorta provided the elastic recoil and distally it was acted as a conduit. So, the diminution in the diameter of abdominal aorta from proximal to distal was being attributed to decrease in the flow volume of blood as it was supplied to the visceral.

In the present study the external diameter of Abdominal aorta at supra renal level was 1.84 cm ± 0.56 cm and at mid aortic level 1.69 ± 0.30cm and at the level just above bifurcation was 1.43 cm ±

0.18cm and mean external diameter was 1.66cm. The study was very close to K.Adachi et al (2000) and Hasan et al (1994). The abdominal aortic diameter was reduced from proximal to distal (Table:3) (chart:8,9&10).

IV. Inter- arterial distance

a.Distance between Celiac Axis to Superior Mesenteric Artery :

According to Gray's Anatomy (40th edition 2008) the superior mesentric artery is 1cm below the celiac axis .R.J Last (1984) mentions that inter arterial distance between the two arteries as 0.5 inch G.J. Romanes (2009)- describes about 1cm between two. Moories (1953) reported 1-22.mm. Wood Jones (1953) reported 0.25 inch Anson & M'C Vay (1936) reported 1-2 cm Cauld well – Anson reported 1-1.9cm , S.R.Satchidhanandam MMC (1987) reported as 0.4 - 1.7cm. Songur et al (2010) reported 1.4 ± 0.26 cm.

According to Cauldwell & Anson the mean distance between celiac and superior mesenteric artery was 1.3cm. So, occasional involvement of

superior mesenteric artery in median arcuate syndrome (Dunbar' syndrome) was not unexpected.

In the present study in 49 specimen the distance was ranged from 0.6 cm to 1.7 cm with a mean distance of 1.1 cm (Table:4) (chart:11). This study was very well compared with Gray (40^{th} ed 2008) Last (1984) Morris (1953) G.J. Roamnes (2009) Cauld well & Anson(1943), S.R.Satchidhanandam MMC (1987) studies.

In two cadavers the distance was high about 1.7cm. A long inter distance was reported by Anson & M'c Vay (1936) Morris (1953).

The distance was less than 0.7 cm in 2 cadavers. This coincided with observation of Morris (1953) and Wood Jones(1953),and S.R.SatchidhanandamMMC(1987).

Distance between SuperiorMesenteric Artery to Inferior Mesenteric Artery :

This distance was rarely reported in text books. According to Cauld Well & Anson (1943), the distance between these 2 arteries

ranged between 3.5 cm in one instance to 10.8 cm as maximum with mean distance of 6.95cm.

A mean distance of 7.3 cm derived from combined data of Heidsieck (1928), Taniguchi (1931) George (1935) Coray & Aubert (1913) located the mode between 7-8 cm.

S.R.Satchidhanandam MMC (1987) reported the distance between the two arteries with a range of 5.2 – 7.2 cm

In the present study the distance was ranged from 5.2 cm- 8.4 cm with mean distance of 6.14cm. The study was very well compared with previous studies(Table:4) (chart:12).

Distance between Inferior Mesenteric Artery to Aortic Bifurcation:

According to Wood burne (1965) Hollinshead (1966) Gray's Anatomy (2008), the distance is 3-4 cm . Basmajian (1980) reported as 4 cm. Wood Jones (1953), G.J. Romanes (2009) Thorek (1954) reported the distance as 1.5 inches. Morries (1953) mentioned that the distance was about 3.7 cm, Anson & M'c vay reported as 2.5-5.5cm

Cauld Well & Anson reported mean distance as 4.2 cm and S.R.Satchidhanandam MMC reported mean distance at 3-5 cm with mean of 3.9 cm.

In the present study the distance between these 2 arteries ranged between 3.2-4.7cm with average distance of 3.7 cm(Table:4) (chart:13). This was very well compared with studies of Wood Burne (1965), Hollinshead (1966) Gray (2009) S.R.SatchidhanandamMMC (1987).

V Course of Abdominal Aorta

The abdominal aorta follows a straight course in front of lumbar vertebra and their intervertebral disc and close to its bifurcation it lies a little left to midline.

Any lateral deviation of abdominal Aorta is of clinical significance since it may mistaken for an aneurysm when palpated through abdominal wall as pulsatile mass (Wood Burne 1965)

In the present study in 2 specimens out of 50 specimens the abdominal aorta slightly deviated to the right.

In out of 50 specimens in one specimen abdominal aorta deviated to left margin of lumbar vertebra.(figure:11,page no:43)

This type of deviations also reported by Feller Wood Burne (1966)

In 2 specimens the abdominal aorta showed a kinking or Pseudocoarctation one at the level of origin of right renal artery and in one at the level of origin of inferior mesenteric artery. This type of kinking was reported by Schellammer et al (1997) and Satheesh Nayak et al (2008). (Figure:10 &11 page no:43)

In one specimen the abdominal aorta showed a dilatation at the level of inferior mesenteric artery and from that level it showed curved course towards left side upto its bifurcation.(figure:5 page no:38)

This type of deviations and dilatations reported by Wood Burne (1966).

VI Variations in branching Pattern

i. In 2% (specimen) there was a common celiaco mesenteric trunk present(figure:14,page no:38). This type of variation was reported by Adachi (1928), Morris (1953),

Michels (1955), Hollinshead (1966), Gray (40th edition 2008) S.R.Satchidhanandam MMC (1987) . *K . Sridhar Varma et al. (2009)*

- According to Michels (1955) origin of celiac artery and superior mesenteric artery as a common trunk from abdominal aorta was rare and it was about less than 1%.
- According to Dunbar (1965) the celiac artery will be compressed by median arcute ligament when it was origination at a higher level.

In the present study the common celiac mesenteric trunk was emerged through the aortic hiatus which was similar to Michales(1955). During the evaluation of Dunbar syndrome the occurrence of common celiac mesenteric trunk can be kept in mind.

ii. In 6% Accessory renal arteries were present. Bilateral renal accessory arteries were present in 4% . (figure :15&16 page no:46)

In 2% (specimen No:22) Unilateral accessory renal artery was present in left side.(figure:17,page no:46)

- According to Gray (2008), Hollinshead , (1964) Last (1987) text books of Anatomy describe that accessory renal arteries are common in 30%.

Notkovich . H (1956) Banowsky (1989), Singh G. et al (1998)_ Bordei et al (2004), Cicekbasi AE et al(2005) Raikas et al (2010) Sonis (2010) Sarita et al (2010) Panyanitinad et al (2010) reported accessory renal arteries more common on left side with 10% have bilateral accessory renal arteries. The present study of variations in renal arteries were coincide with them.

iii) In 2% the gonadal arteries were arised from renal arteries , instead of abdominal aorta. (figure:18, page no:47)

Notkovich (1956), Singh.G et al (1998) Sarita Sylvia et al *Cicekcibasi AE*, Ziylan T, Salbacak A, et al (2002) Soni. S. Wadhwa. A et al (2010) Panyantinad et al (2010) reported bilateral renal accessory arteries with variant origin of gonadal arteries from renal arteries. The present study of variant origin of gonadal arteries from renal arteries was coincide with them mainly with Singh.G et al(1998).

iv) In 2% of the specimen the inferior phrenic artery was originated from the renal artery on the right side,and on the left side it was originated from the celiac trunk.(figure:19 page no:48) This type of pattern was reported by Pick. J & Anson (1940) Piao et al (1998), Loukas et al (2005), Gokan et al (2001) Gown D.I et al (2001) Bakhiet et al (2004) Deepthinath. R et al (2006)

v) In one specimen the middle supra renal artery on the right side was originated from renal artery as a common trunk along with inferior phrenic artery. (figure:19 page no:48)

This type of branching pattern was reported by Deepthinath.R et al (2006)

vi) In one specimen (45) higher lever origin of left gonadal artery from abdominal aorta in its lateral aspect very close to left renal vein. Here the artery arched over the left renal vein to follow its further course.(figure:6 page no:38) This type of arching of gonadal artery over the left renal vein was reported by Notkovich (1956), Naito et al (2006) Skoog et al (1997) Lellie et al (2007) Bando Padhyay et al (2009)

Variant origin of testicular artery, inferior phrenic artery and middle supra renal artery from renal artery instead of abdominal aorta was important for endovascular renal interventions and kidney transplantations.

Siniluto et al (1988), Riddel et al (2004) reported testicular infraction and left adrenal infarction following ethanol embolisation of renal neoplasm.

Accessory renal arteries arise from aorta either above or below the main renal artery and follow it to the hilum. It is important to be aware that accessory renal arteries are end arteries, if an accessory is damaged, the part of kidney which is supplied by it is likely to become ischemic.

CONCLUSION

- The abdominal aorta passed through the aortic hiatus of diaphragm at the level of lower border of twelfth thoracic vertebra in all 50 specimens.
- Vertebral level of all the unpaired and paired visceral branches- celiac artery, superior mesenteric artery, inferior mesenteric artery, renal arteries , gonadal arteries were noted.
- Vertebral level of bifurcation of abdominal aorta was noted.
- The length of abdominal aorta from aortic bifurcation to origin of inferior phrenic arteries which is the upper most limit of abdominal aorta was measured.
- The width of abdominal aorta at supra renal level, mid aortic level and just above bifurcation was were measured.
- Inter arterial distance between Celiac axis to Superior mesenteric artery (CA to SMA),Superior mesenteric artery to inferior mesenteric artery (SMA- IMA), Inferior mesenteric artery (IMA-AB) were measured.

- ❖ The course of abdominal aorta and its variations in shape were noted.
- ❖ Variations in branching pattern of abdominal aorta were noted

The present study revealed a variety of variations.

- ➢ The vertebral level of origin of celiac axis was in 32% at inter vertebral disc between twelfth thoracic vertebra and first lumbar vertebra (IVD T12-L1), in 40% at first lumbar vertebra(L1), in 28% at lower border of twelfth thoracic vertebra. (LT12).
- ➢ The vertebral level of origin of superior mesenteric artery was in 96% at first lumbar vertebra (L1),in 2% at inter vertebral disc between twelfth thoracic vertebra and first lumbar vertebra (IVD T12-L1) and in 2 % at lower border of twelfth thoracic vertebra (LT12).
- ➢ The origin of inferior mesenteric artery was 72% at the level of third lumbar vertebra (L3), 22% at the level of inter vertebral disc between third lumbar and fourth lumbar vertebra (IVD L3-L4) and 2% at inter vertebral disc between (IVD L2-L3) and 4% at lower border of second lumbar vertebra (LL2).

- The origin or renal arteries in 78% on the right side ,in 74% on the left side at first lumbar vertebra (L1). In 16% on the right side and 20% on the left side it was at second lumbar vertebra (L2). In 4% on the right side and 2% on the left side it was at the level of inter vertebral disc between second lumbar and third lumbar vertebra (IVD L1-L2). In 60% right renal artery was proximal than the left renal artery and in 16% both arteries were at same level. In 18% the left one was proximal than the right renal artery.

- The origin of gonadal arteries in 94% on both sides were at the level of second lumbar vertebra(L2). In 4% the right gonadal artery was at lower level than the left gonadal artery.

- The vertebral level of bifurcation of abdominal aorta in 62% at body of fourth lumbar vertebra (BL4) , in 16% at lower border of fourth lumbar vertebra (LL4) , in 18% at upper border of fourth lumbar(U L4) , in 2% lower border of third lumbar vertebra (LL3) and in 2% at the level of inter vertebral disc between fourth lumbar and fifth lumbar vertebra (IVD L4-L5).

- The length of abdominal aorta ranged between 10.4 to 13.1 cm with mean length of 11cm.
- The width of abdominal aorta decreased from proximal to distal it was about 1.84 ± 0.56 cm at supra renal level and 1.69 ± 0.30cm at mid aortic level and 1.43 ±0.18 cm at just above bifurcation.
- Inter arterial distance between celiac artery to superior mesenteric artery (CA-SMA) with mean value of 1.1 cm, superior mesenteric artery to inferior mesenteric artery (SMA-IMA) = 6.14cm and inferior mesenteric artery to aortic bifurcation (IMA – AB) = 3.9cm.
- Lateral deviations of abdominal aorta in 6%.
- Kinking of aorta in 4%.
- Dilatation of aorta in 2% .
- Common celiaco mesenteric trunk in 2%.
- Accessory renal arteries in 6% (4% bilateral – 2% unilateral left)

- Variant origin of gonadal arteries from renal artery in 2%.
- The renal origin of inferior phrenic artery along with middle supra renal artery on right side in 2%.
- In all the 50 specimens 4 lumbar pairs were seen.
- In none of the specimen median sacral agenesis seen.
- The present study of morphology of abdominal aorta was thus helpful in regards to diagnosis and management.

STUDY OF MORPHOLOGY OF ABDOMINAL AORTA IN 50 SPECIMENS

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VERTEBRAL LEVEL OF BRANCHES								
Specimens	CA	SMA	IMA	RRA	LRA	RGA	LGA	AB
Specimen 1	LT 12	UL 1	LL 3	LL 1	LL 1	L2	L2	BL 4
Specimen 2	LT 12	UL 1	LL 3	UL 2	UL 2	L2	L2	BL 4
Specimen 3	LT 12	BL 1	LL 3	LL 1	LL 1	L2	L2	BL 4
Specimen 4	LT 12	BL 1	LL 3	LL 1	LL 1	L2	L2	BL 4
Specimen 5	T12 - L1	UL 1	L2 - L3	L1 - L2	LL 1	L2	L2	UL 4
Specimen 6	UL 1	BL 1	LL 3	UL 2	UL 2	L2	L2	BL 4
Specimen 7	UL 1	BL 1	LL 3	LL 1	LL 1	L2	L2	BL 4
Specimen 8	UL 1	BL 1	LL 3	LL 1	LL 1	L2	L2	BL 4
Specimen 9	UL 1	BL 1	LL 3	UL 2	UL 2	L2	L2	UL 4
Specimen 10	UL 1	BL 1	LL 3	LL 1	UL 2	L2	L2	BL 4
Specimen 11	UL 1	BL 1	LL 3	LL 1	LL 1	L2	L2	UL 4
Specimen 12	UL 1	BL 1	LL 3	UL 2	UL 2	L2	L2	BL 4
Specimen 13	UL 1	BL 1	LL 3	LL 1	LL 1	L2	L2	BL 4
Specimen 14	UL 1	BL 1	LL 3	LL 1	LL 1	L2	L2	UL 4
Specimen 15	UL 1	BL 1	L3 - L4	LL 1	UL 2	L2	L2	BL 4
Specimen 16	LT 12	BL 1	LL 3	UL 2	UL 2	L2	L2	BL 4
Specimen 17	BL 1	LL 1	LL 3	LL 1	LL 1	L2	L2	BL 4
Specimen 18	T12 - L1	UL 1	BL 3	BL 1	BL1	L2	L2	UL 4
Specimen 19	BL 1	LL 1	L3 - L4	LL 1	LL 1	L2	L2	LL 4
Specimen 20	BL 1	LL 1	L3 - L4	LL 1	LL 1	L2	L2	LL 4
Specimen 21	BL 1	LL 1	LL 3	UL 2	UL 2	L2	L2	BL 4
Specimen 22	T12 - L1	UL 1	BL 3	LL 1	BL 1, UL 2	L2	L2	LL 4
Specimen 23	BL 1	LL 1	LL 3	LL 1	LL 1	L2	L2	BL 4
Specimen 24	UL 1	BL 1	LL 3	L1 - L2	L1 -L2	L2	L2	BL 4
Specimen 25	UL 1	BL 1	LL 3	LL 1	LL 1	L2	L2	BL 4
Specimen 26	LT 12	BL 1	L3 - L4	LL 1	LL 1	L2	L2	LL 4
Specimen 27	LT 12	BL 1	L3 - L4	UL 2	UL 2	L2	L2	LL 4
Specimen 28	LT 12	BL 1	L3 - L4	LL1	LL1	L2	L2	LL4
Specimen 29	UL 1	BL 1	LL 3	LL 1	LL 1	L2	L2	BL 4
TABLE -1								
VERTEBRAL LEVEL OF BRANCHES								

Specimens	CA	SMA	IMA	RRA	LRA	RGA	LGA	AB
Specimen 30	UL 1	BL 1	LL 3	LL 1	LL 1	L2	L2	BL 4
Specimen 31	UL 1	BL 1	LL 3	LL 1	LL 1	L2	L2	BL 4
Specimen 32	LT 12	LT 12	L3 - L4	UL 1	UL 1	L2	L2	L4 - 5
Specimen 33	LT 12	T12 - L1	BL 2	UL 1	UL 1	RL	LL1	LL 3
Specimen 34	LT 12	UL 1	L3 - L4	LL 1	LL 1	L2	L2	BL 4
Specimen 35	LT 12	UL 1	L3 - L4	LL 1	LL 1	L2	L2	BL 4
Specimen 36	T12 - L1	UL 1	LL 3	LL 1	LL 1	L2	L2	BL 4
Specimen 37	T12 - L1	UL 1	LL 3	UL 2	UL 2	L2	L2	BL 4
Specimen 38	T12 - L1	UL 1	LL 3	LL 1	LL 1	L2	L2	BL 4
Specimen 39	T12 - L1	UL 1	LL 3	LL 1	LL 1	L2	L2	BL 4
Specimen 40	T12 - L1	UL 1	LL 3	LL 1	LL 1	L2	L2	BL 4
Specimen 41	LT 12	UL 1	L3 - L4	LL 1	LL 1	L2	L2	BL 4
Specimen 42	T12 - L1	UL 1	LL 3	LL 1	LL 1	L2	L2	BL 4
Specimen 43	T12 - L1	UL 1	BL 3	BL 1	LL 1	L2	L1 -2	UL 4
Specimen 44	LT 12	BL 1	LL 2	UL 1, LL 1	BL 1, LL 1	VO	VO	UL 4
Specimen 45	T12 - L1	UL 1	LL 3	BL 1	LL 1	L2 - L3	LL1	LL 4
Specimen 46	T12 - L1	UL 1	BL 3	LL 1	LL 1	L2	L2	LL 4
Specimen 47	T12 - L1	UL 1	L3 - L4	LL 1	LL 1	L2	L2	BL 4
Specimen 48	T12 - L1	UL 1	BL 3	LL 1	LL 1	L2	L2	UL 4
Specimen 49	T12 - L1	UL 1	LL 3	LL 1	LL 1	L2	L2	BL 4
Specimen 50	T12 - L1	UL 1	BL 3	BL 1	LL 1	L2	L2	UL 4

(L1-1st Lumbar vertebra, T12- 12thThoracic vertebra, BLI - Body of 1st lumbar vertebra , LL1-Lower border of 1st Lumbar vertebra T12-L1 intervertebral disc between 12th thoracic and 1st lumbar vertebra; L2-2nd lumbar vertebra, L3-3rd lumbar vertebra; BL3- Body of 3rd lumbar vertebra; LL3- lower border of 3rd lumbar vertebra; L4-4th lumbar vertebra; BL4- Body of 4th lumbar vertebra; LL4 – lower borders of 4th lumbar vertebra.)

TABLE-2

SPECIMENS	TOTAL LENGTH OF AA
SPECIMEN 1	10.9
SPECIMEN 2	11.5
SPECIMEN 3	12
SPECIMEN 4	11.7
SPECIMEN 5	11.4
SPECIMEN 6	12.4
SPECIMEN 7	12.5
SPECIMEN 8	12.3
SPECIMEN 9	12.7
SPECIMEN 10	12.1
SPECIMEN 11	12.4
SPECIMEN 12	10.8
SPECIMEN 13	11.7
SPECIMEN 14	11.6
SPECIMEN 15	11.6
SPECIMEN 16	11.9
SPECIMEN 17	11.4
SPECIMEN 18	11
SPECIMEN 19	10.4
SPECIMEN 20	11
SPECIMEN 21	10.5
SPECIMEN 22	12.5
SPECIMEN 23	11.2
SPECIMEN 24	10.9
SPECIMEN 25	11.5
SPECIMEN 26	12.7
SPECIMEN 27	11.9
SPECIMEN 28	11.5
SPECIMEN 29	11
SPECIMEN 30	10.4
SPECIMEN 31	10.8
SPECIMEN 32	13.1
SPECIMEN 33	11.4
SPECIMEN 34	11.5
SPECIMEN 35	12
SPECIMEN 36	12.4
SPECIMEN 37	11.9
SPECIMEN 38	12.1
SPECIMEN 39	11.2
SPECIMEN 40	11.7
SPECIMEN 41	11.2
SPECIMEN 42	11.8
SPECIMEN 43	11.4
SPECIMEN 44	12
SPECIMEN 45	12.6
SPECIMEN 46	12.3
SPECIMEN 47	11.2
SPECIMEN 48	10.8
SPECIMEN 49	10.9
SPECIMEN 50	11.1

TABLE-3

SPECIMEN	SUPRA REANAL AORTIC DIAMETER cm	MID AORTIC DIAMETER cm	ABOVE BIFUR DIAMETER cm
Specimen 1	1.94	1.82	1.44
Specimen 2	1.92	1.78	1.42
Specimen 3	1.94	1.88	1.32
Specimen 4	1.91	1.8	1.52
Specimen 5	1.92	1.72	1.49
Specimen 6	1.94	1.74	1.43
Specimen 7	1.92	1.81	1.41
Specimen 8	1.93	1.66	1.42
Specimen 9	1.79	1.67	1.45
Specimen 10	1.76	1.62	1.43
Specimen 11	1.74	1.71	1.44
Specimen 12	1.82	1.72	1.32
Specimen 13	1.85	1.82	1.35
Specimen 14	1.93	1.77	1.38
Specimen 15	1.92	1.81	1.32
Specimen 16	1.98	1.69	1.34
Specimen 17	1.75	1.62	1.37
Specimen 18	1.74	1.59	1.39
Specimen 19	1.72	1.57	1.32
Specimen 20	1.68	1.5	1.49
Specimen 21	1.66	1.52	1.42
Specimen 22	1.68	1.53	1.44
Specimen 23	1.69	1.51	1.4
Specimen 24	1.69	1.51	1.41
Specimen 25	1.68	1.51	1.41

SPECIMEN	SUPRA REANAL AORTIC DIAMETER cm	MID AORTIC DIAMETER cm	ABOVE BIFUR DIAMETER cm
Specimen 26	1.79	1.55	1.44
Specimen 27	1.82	1.61	1.41
Specimen 28	2.2	1.92	1.73
Specimen 29	2.12	1.9	1.7
Specimen 30	1.97	1.84	1.45
Specimen 31	1.92	1.82	1.46
Specimen 32	2.31	1.99	1.83
Specimen 33	1.96	1.84	1.39
Specimen 34	1.75	1.64	1.33
Specimen 35	1.79	1.69	1.42
Specimen 36	1.7	1.59	1.39
Specimen 37	1.68	1.55	1.42
Specimen 38	1.72	1.59	1.38
Specimen 39	1.74	1.57	1.36
Specimen 40	1.83	1.69	1.3
Specimen 41	1.94	1.82	1.41
Specimen 42	1.92	1.79	1.44
Specimen 43	1.98	1.84	1.45
Specimen 44	2.31	1.97	1.83
Specimen 45	1.72	1.68	1.43
Specimen 46	1.52	1.38	1.3
Specimen 47	1.68	1.54	1.46
Specimen 48	1.94	1.62	1.48
Specimen 49	1.74	1.61	1.36
Specimen 50	1.72	1.6	1.33

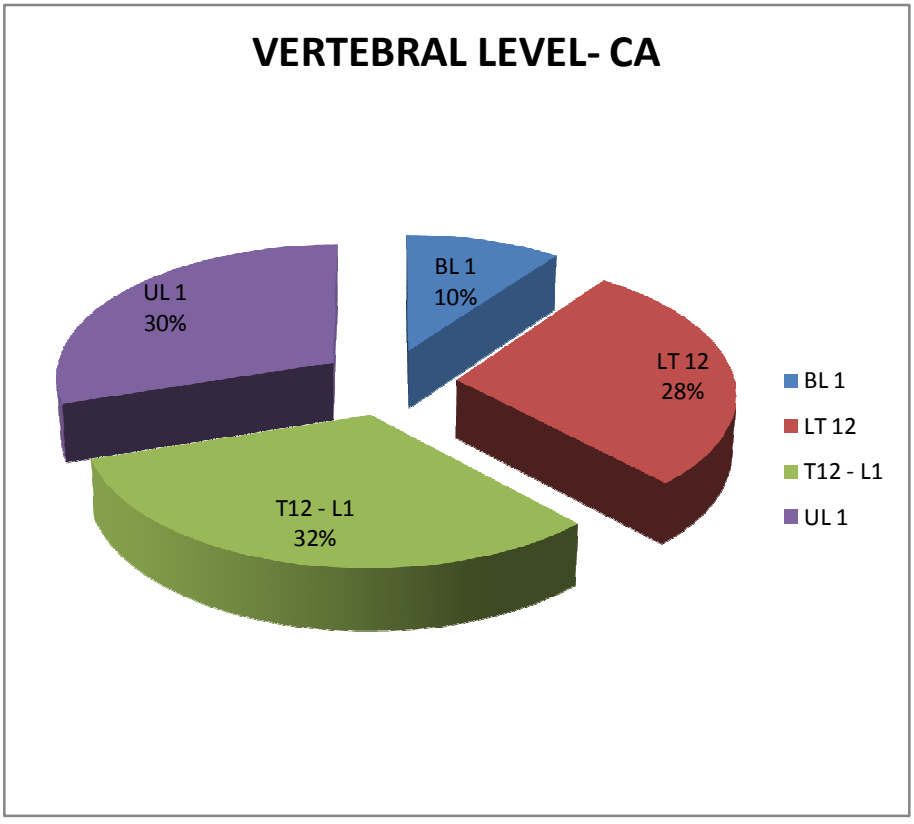
TABLE-4

SPECIMENS	Distance between AB-CA (cm)	Distance between CA-SMA (cm)	Distance between SMA-IMA (cm)	Distance between IMA-AB (cm)
Specimen 1	10.4	0.6	5.7	4.1
Specimen 2	11	1.2	5.9	3.9
Specimen 3	11.5	1.1	6.1	4.3
Specimen 4	11.2	1.2	5.9	4.1
Specimen 5	10.9	0.7	5.7	4.5
Specimen 6	11.9	1	6.6	4.3
Specimen 7	12	1.2	6.9	3.9
Specimen 8	11.8	1.3	6.5	4.1
Specimen 9	11.6	1.3	6.4	3.9
Specimen 10	11.6	1.5	5.8	4.3
Specimen 11	11.9	1.3	7	3.6
Specimen 12	10.6	1.3	5.2	3.8
Specimen 13	11.2	1.7	5.7	3.8
Specimen 14	11.1	1.5	5.5	4.1
Specimen 15	11.1	1.2	5.2	4.7
Specimen 16	11.4	1.5	5.7	4.2
Specimen 17	10.9	0.7	6.3	3.9
Specimen 18	10.5	0.8	6.1	3.6
Specimen 19	9.9	0.7	6	3.2
Specimen 20	10.5	0.9	6.1	3.5
Specimen 21	10	0.7	6	3.3
Specimen 22	12	1.5	6.4	4.1
Specimen 23	10.7	0.8	6.1	3.8
Specimen 24	10.4	0.6	6.3	3.5
Specimen 25	11	1.1	5.8	4.1

SPECIMENS	Distance between AB-CA (cm)	Distance between CA-SMA (cm)	Distance between SMA-IMA (cm)	Distance between IMA-AB (cm)
Specimen 26	12.2	1.2	6.8	4.2
Specimen 27	11.4	1.1	5.9	4.4
Specimen 28	11	1.3	5.5	4.2
Specimen 29	10.6	1.5	5.2	3.9
Specimen 30	9.9	0.8	5.4	3.7
Specimen 31	10.3	1.1	5.6	3.6
Specimen 32	13.1	0	8.4	4.7
Specimen 33	10.9	1.2	5.9	3.8
Specimen 34	11	1.2	6.2	3.6
Specimen 35	11.5	1.2	6.9	3.4
Specimen 36	11.9	1.3	6.5	4.1
Specimen 37	11.4	1.5	6.2	3.7
Specimen 38	11.7	1.7	6.2	3.8
Specimen 39	10.7	0.9	6.3	3.5
Specimen 40	11.2	0.7	6.8	3.7
Specimen 41	10.7	0.8	6.5	3.5
Specimen 42	11.3	1	6.5	3.8
Specimen 43	10.9	1.1	6.4	3.4
Specimen 44	11.5	1.2	6.2	4.1
Specimen 45	12.1	1.2	7.1	3.8
Specimen 46	11.8	1.5	6.8	3.5
Specimen 47	10.7	1.3	5.9	3.4
Specimen 48	10.3	1.2	5.6	3.5
Specimen 49	10.4	1.1	5.5	3.8
Specimen 50	10.6	1.2	5.6	3.8

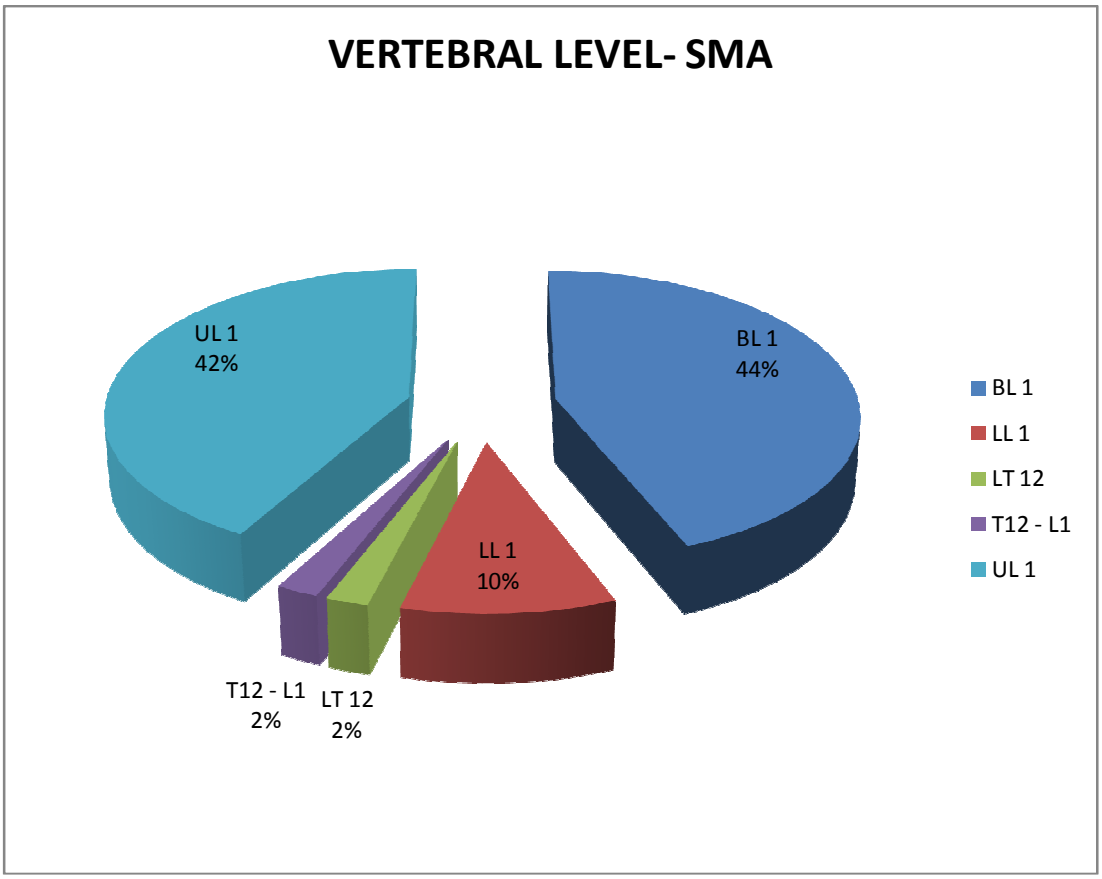
ROW LABELS	COUNT OF CELIAC AXIS
Body of first lumbar vertebra	5
Lower border of twelfth thoracic vertebra	14
Inter vertebral disc between twelfth thoracic & First lumbar vertebra	16
Upper border of first lumbar vertebra	15

CHART-1



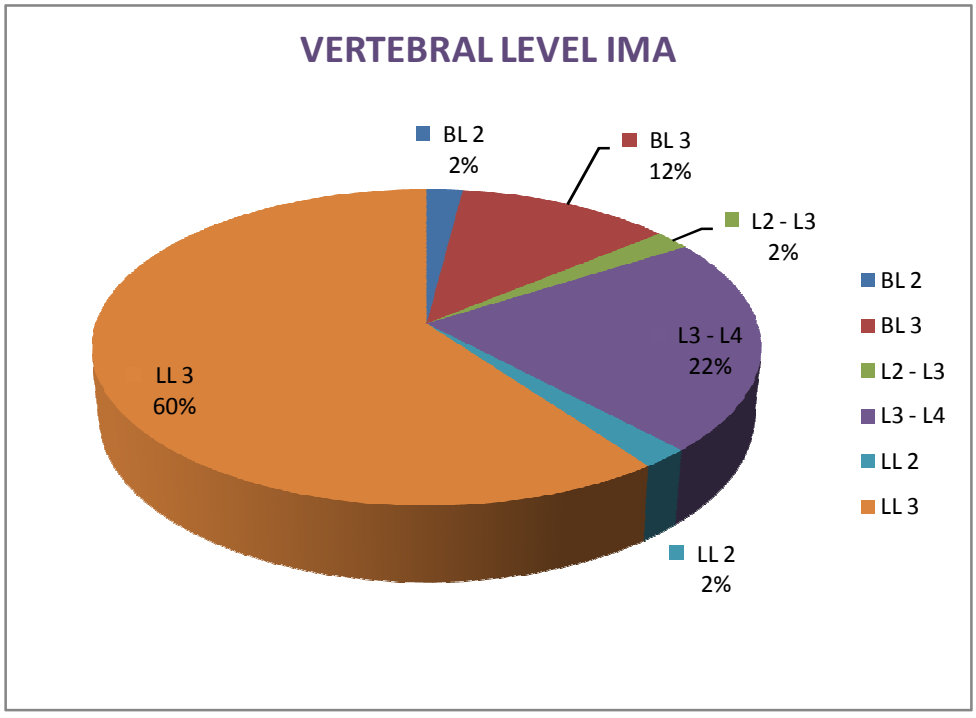
ROW LABELS	COUNT OF SUPERIOR MESENTRIC ARTERY
Body of first lumbar vertebra	22
Lower border of first lumbar vertebra	5
Lower border of twelfth thoracic vertebra	1
Inter vertebral disc between twelfth thoracic & First lumbar vertebra	1
Upper border of first lumbar vertebra	21

CHART- 2



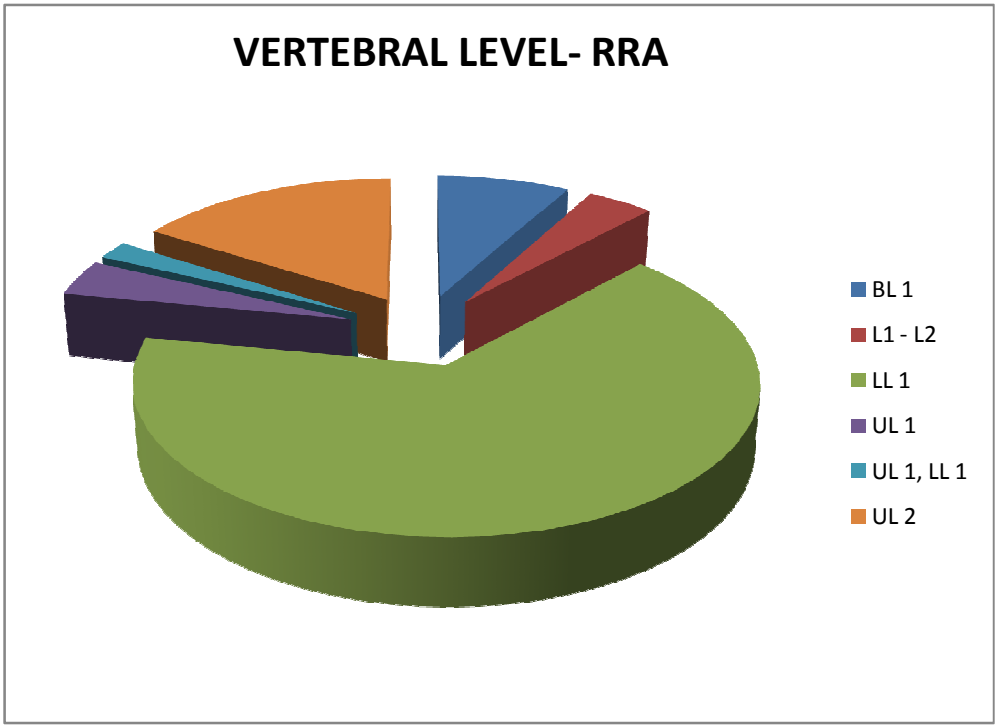
ROW LABELS	COUNT OF INFERIOR MESENTERICARTERY
Body of second lumbar vertebra	1
Body of third lumbar vertebra	6
Inter vertebral disc between second & third lumbar vertebra	1
Inter vertebral disc between third & fourth lumbar vertebra	11
Lower border of second lumbar vertebra	1
Lower border of third lumbar vertebra	30

CHART- 3



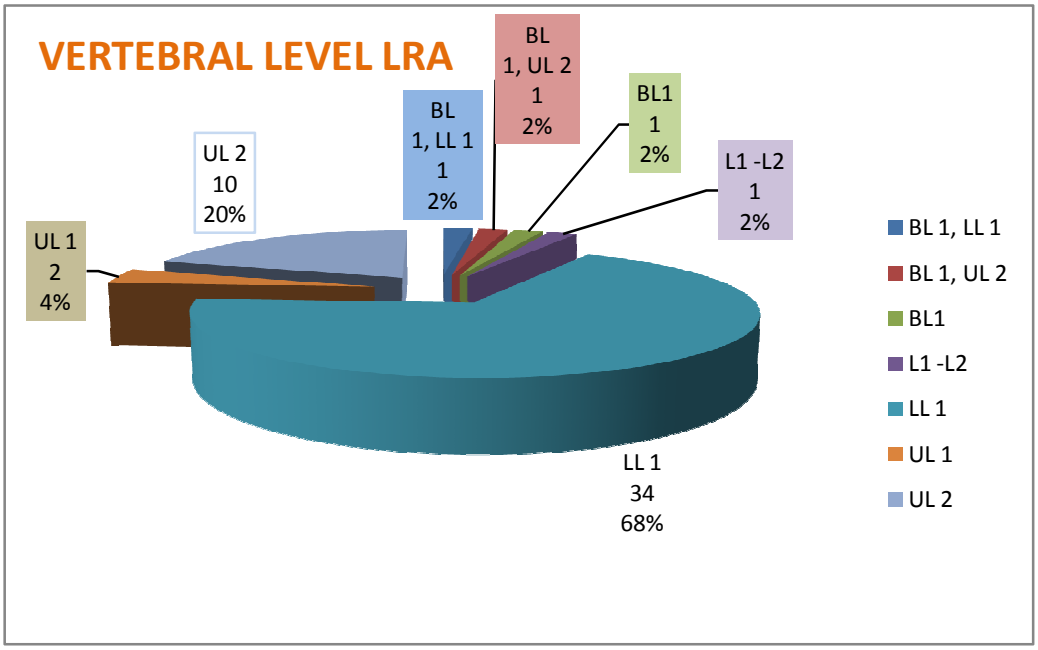
ROW LABELS	COUNT OF RIGHT RENAL ARTERY
Body of first lumbar vertebra	4
Inter vertebral disc between first & second lumbar vertebra	2
Lower border of second lumbar vertebra	33
Upper border of first lumbar vertebra	2
Upper Border Of First Lumbar Vertebra & Lower border of first lumbar vertebra	1
Upper border of second lumbar vertebra	8

CHART- 4



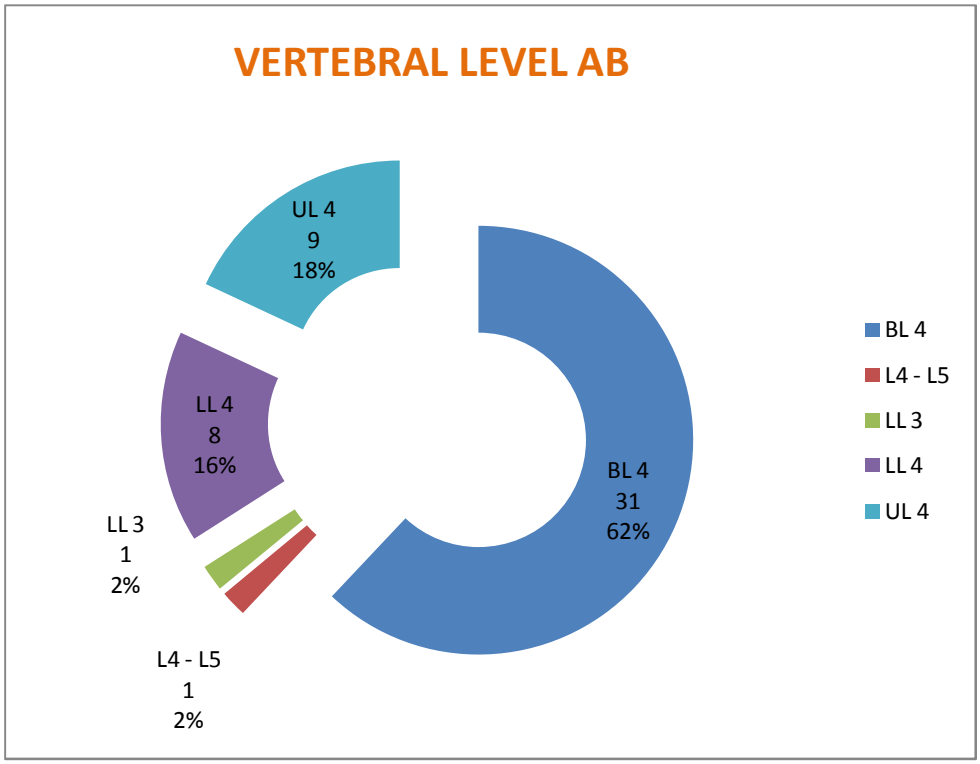
ROW LABELS	COUNT OF LEFT RENAL ARTERY
Body of first lumbar vertebra & Lower border of first lumbar vertebra	1
Body of first lumbar vertebra & Upper border of second lumbar vertebra	1
Body of first lumbar vertebra	1
Inter vertebral disc between first & second lumbar vertebra	1
Lower border of first lumbar vertebra	34
Upper border of first lumbar vertebra	2
Upper border of second lumbar vertebra	10

CHART- 5



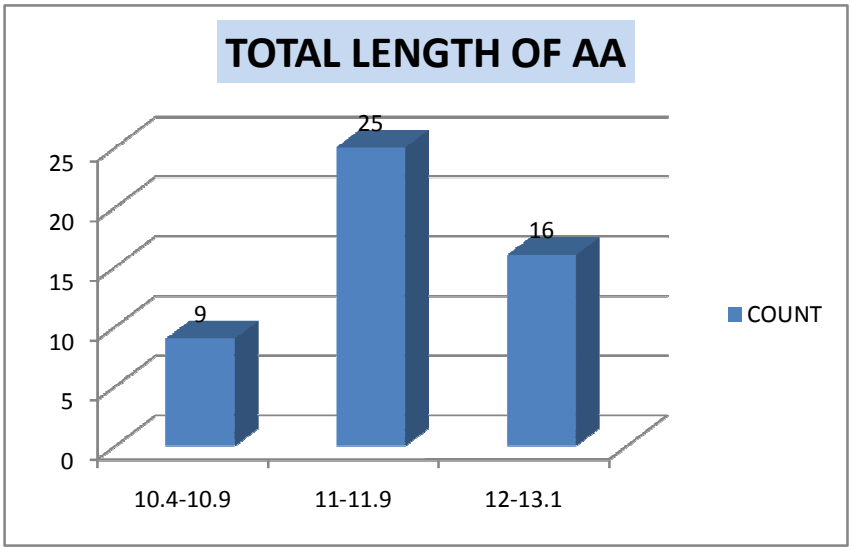
ROW LABELS	COUNT OF AORTIC BIFUR
Body of fourth lumbar vertebra	31
Inter vertebral disc between fourth & fifth lumbar vertebra	1
Lower border of third lumbar vertebra	1
Lower border of fourth lumbar vertebra	8
Upper border of fourth lumbar vertebra	9

CHART - 6



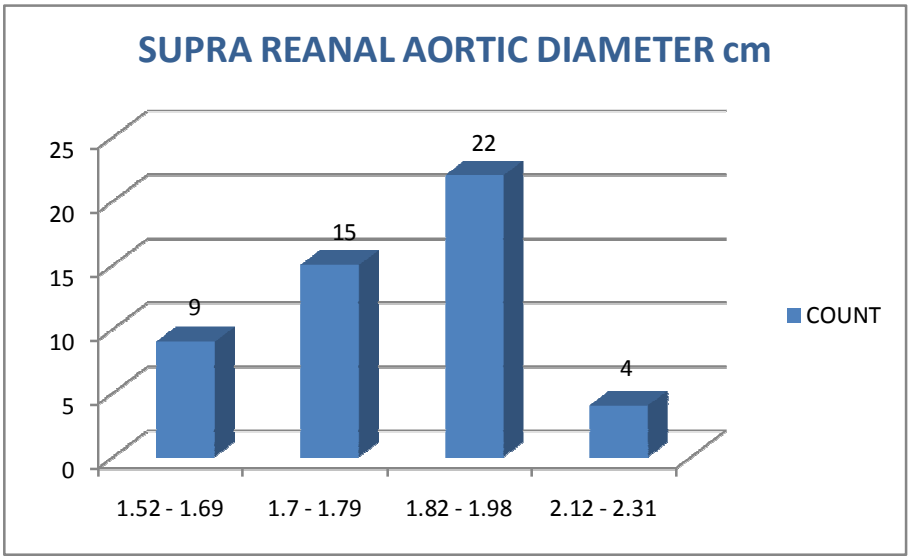
RANGE	COUNT
10.4-10.9	9
11-11.9	25
12-13.1	16

CHART - 7



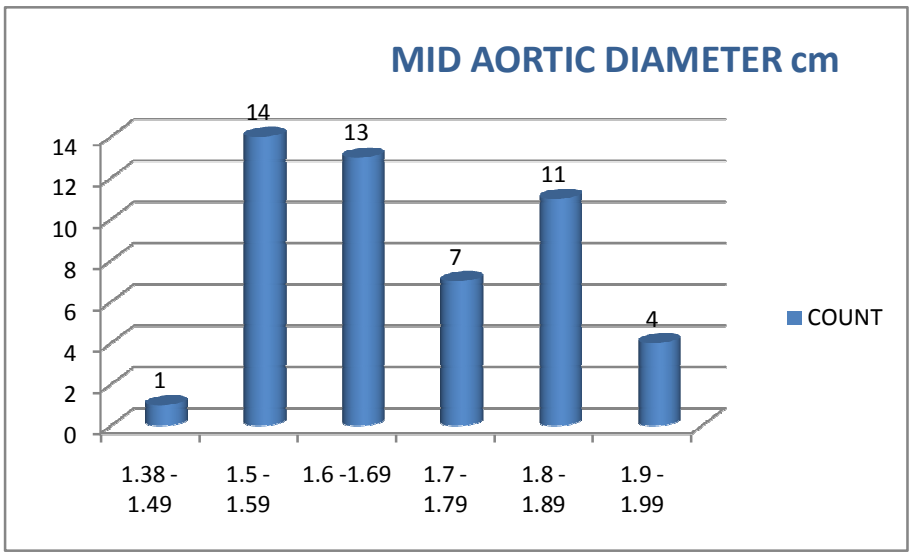
RANGE	COUNT
1.52 - 1.69	9
1.7 - 1.79	15
1.82 - 1.98	22
2.12 - 2.31	4

CHART - 8



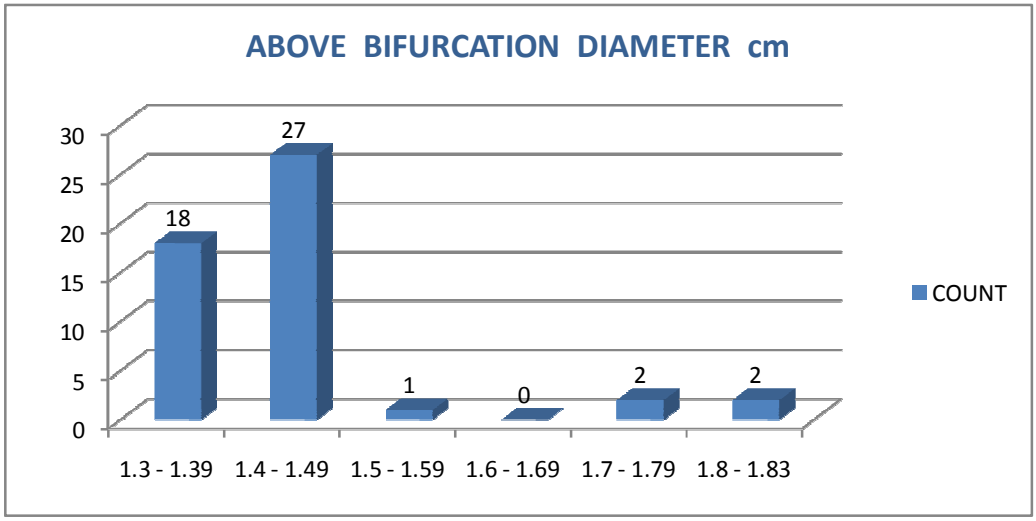
RANGE	COUNT
1.38 - 1.49	1
1.5 - 1.59	14
1.6 -1.69	13
1.7 - 1.79	7
1.8 - 1.89	11
1.9 - 1.99	4
	50

CHART - 9



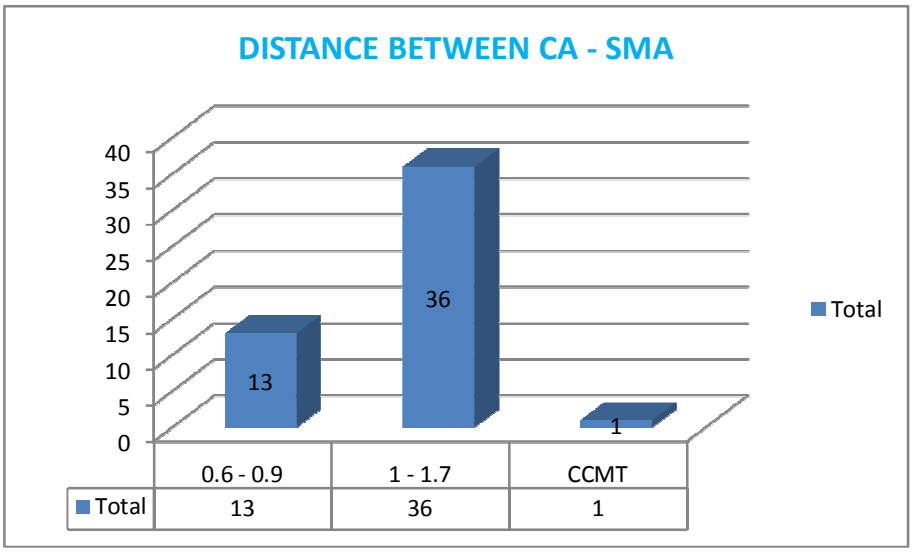
RANGE	COUNT
1.3 - 1.39	18
1.4 - 1.49	27
1.5 - 1.59	1
1.6 - 1.69	0
1.7 - 1.79	2
1.8 - 1.83	2

CHART - 10



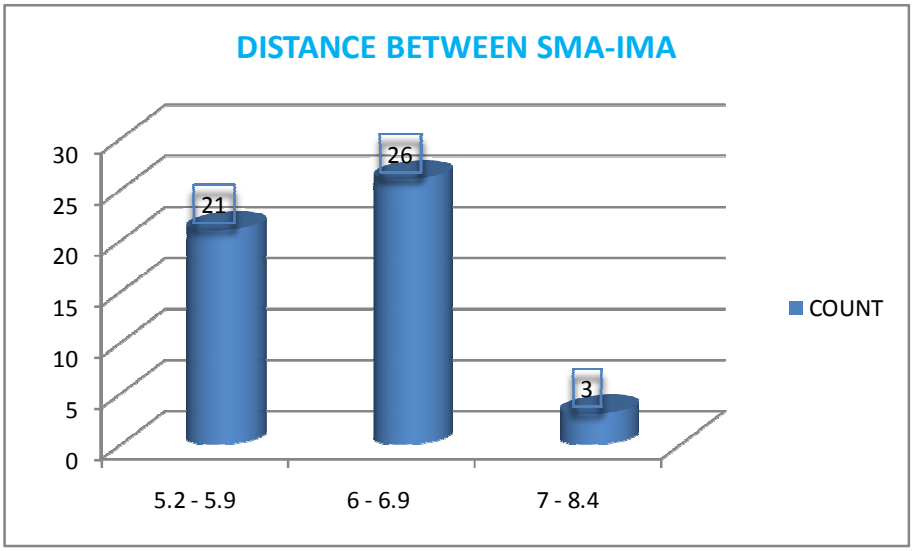
ROW LABELS	SUM OF COUNT
0.6 - 0.9	13
1 - 1.7	36
Common Celiac Mesenteric Trunk	1

CHART -11



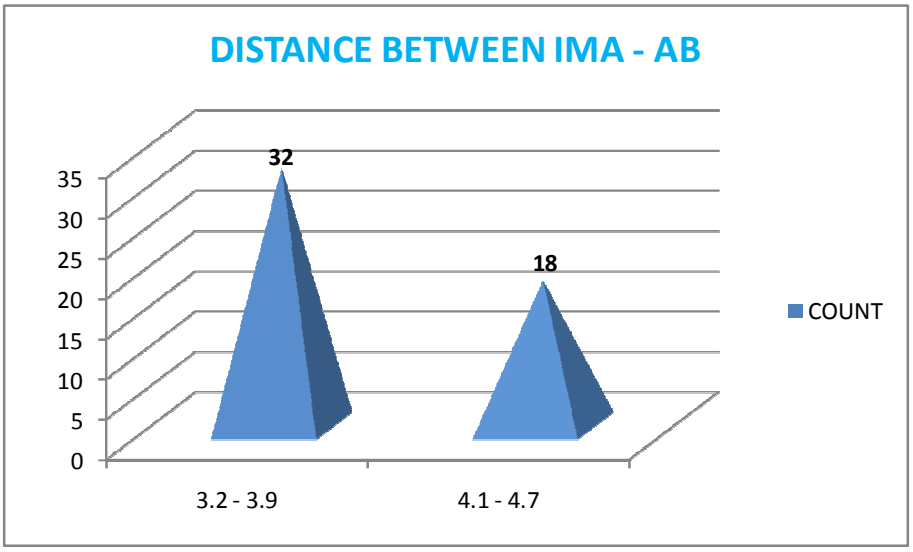
RANGE	COUNT
5.2 - 5.9	21
6 - 6.9	26
7 - 8.4	3

CHART - 12



RANGE	COUNT
3.2 - 3.9	32
4.1 - 4.7	18

CHART – 13



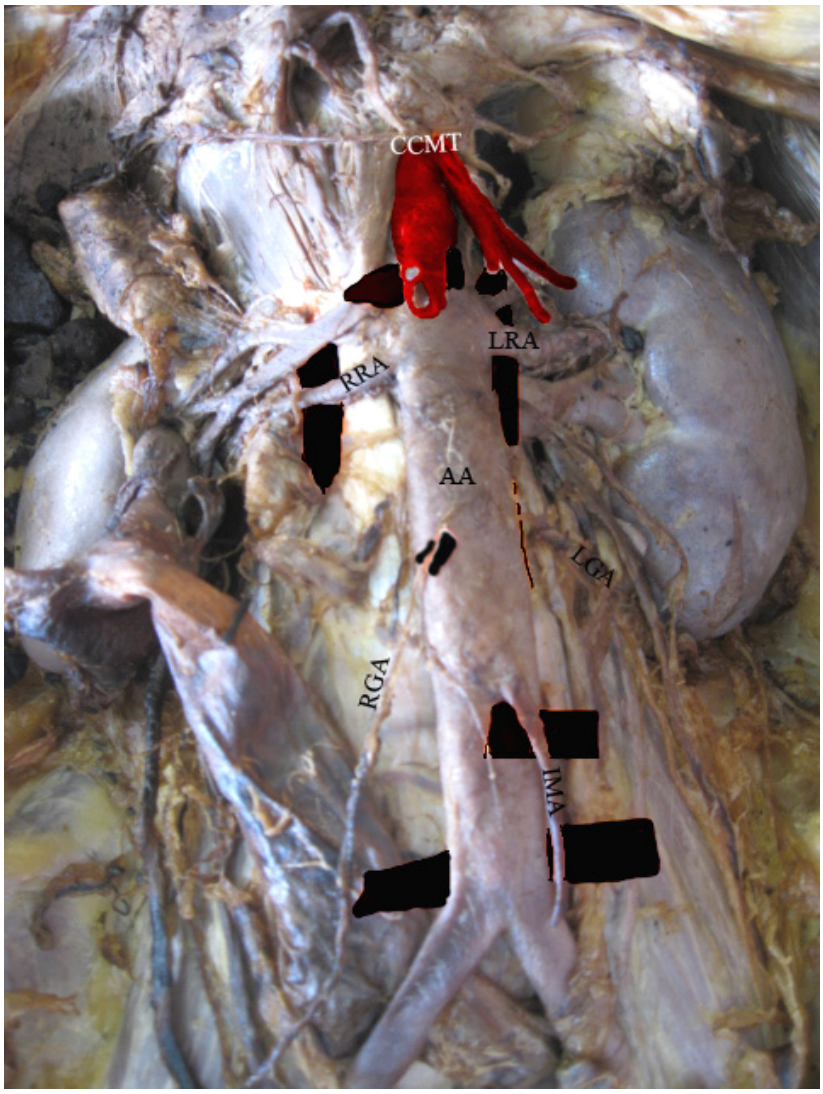


Figure: 1

Shows common celiaco mesenteric trunk (CCMT)

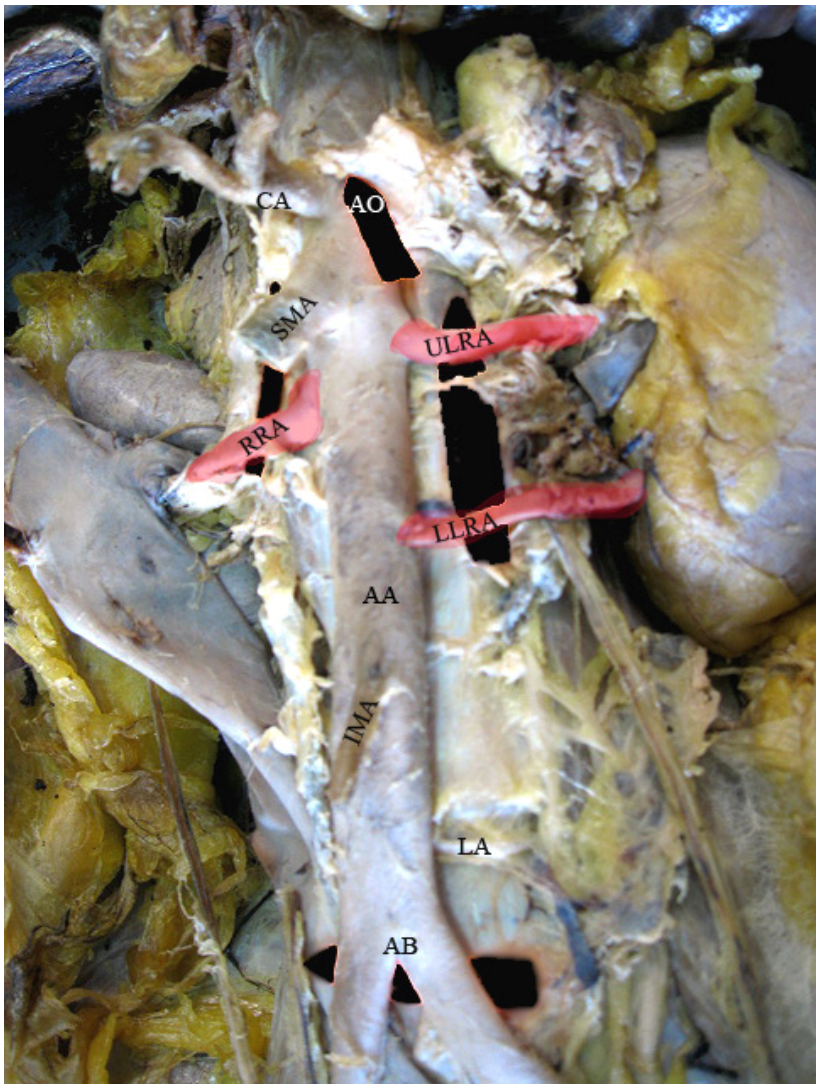


Figure: 2

Unilateral accessory renal arteries on the left side.

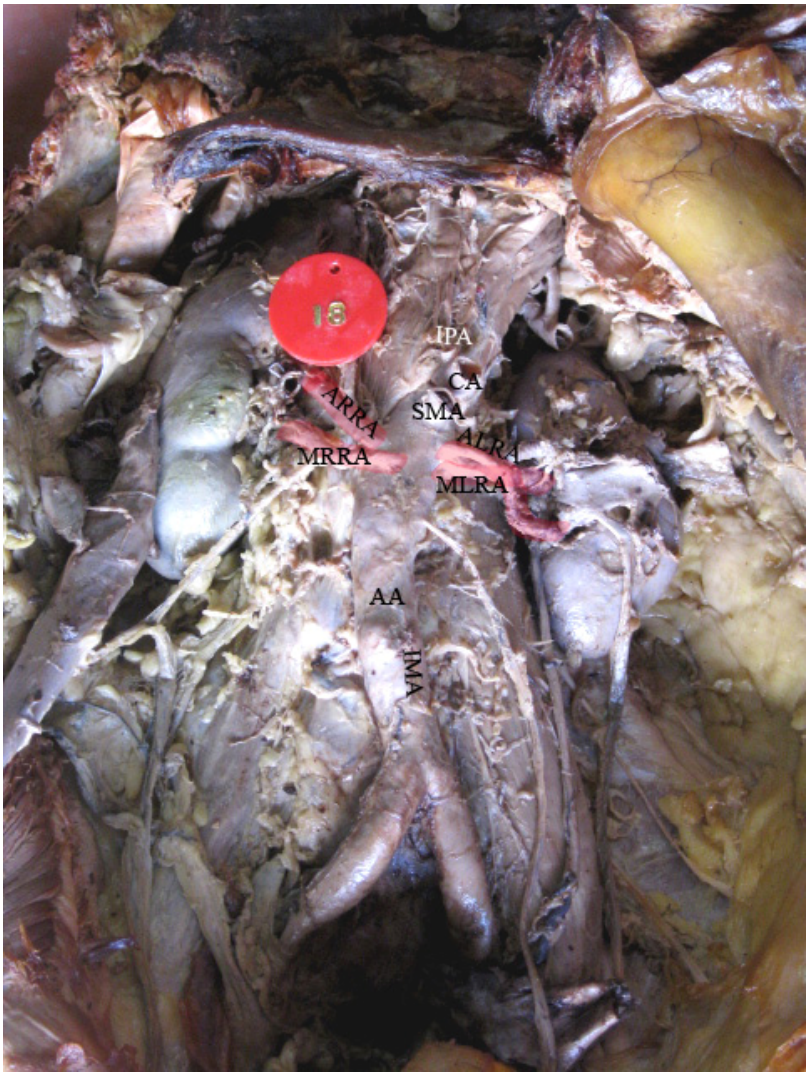


Figure: 3

Bilateral accessory renal arteries were seen.

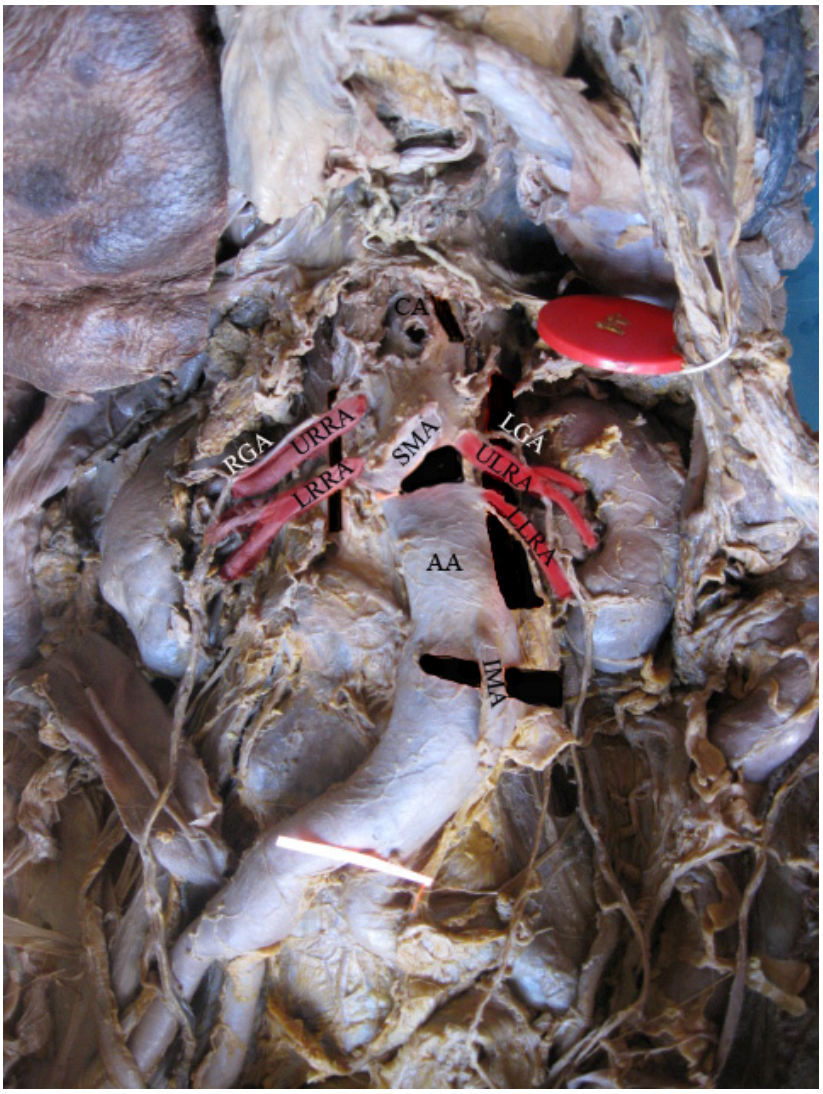


Figure: 4

Bilateral accessory renal arteries were seen.

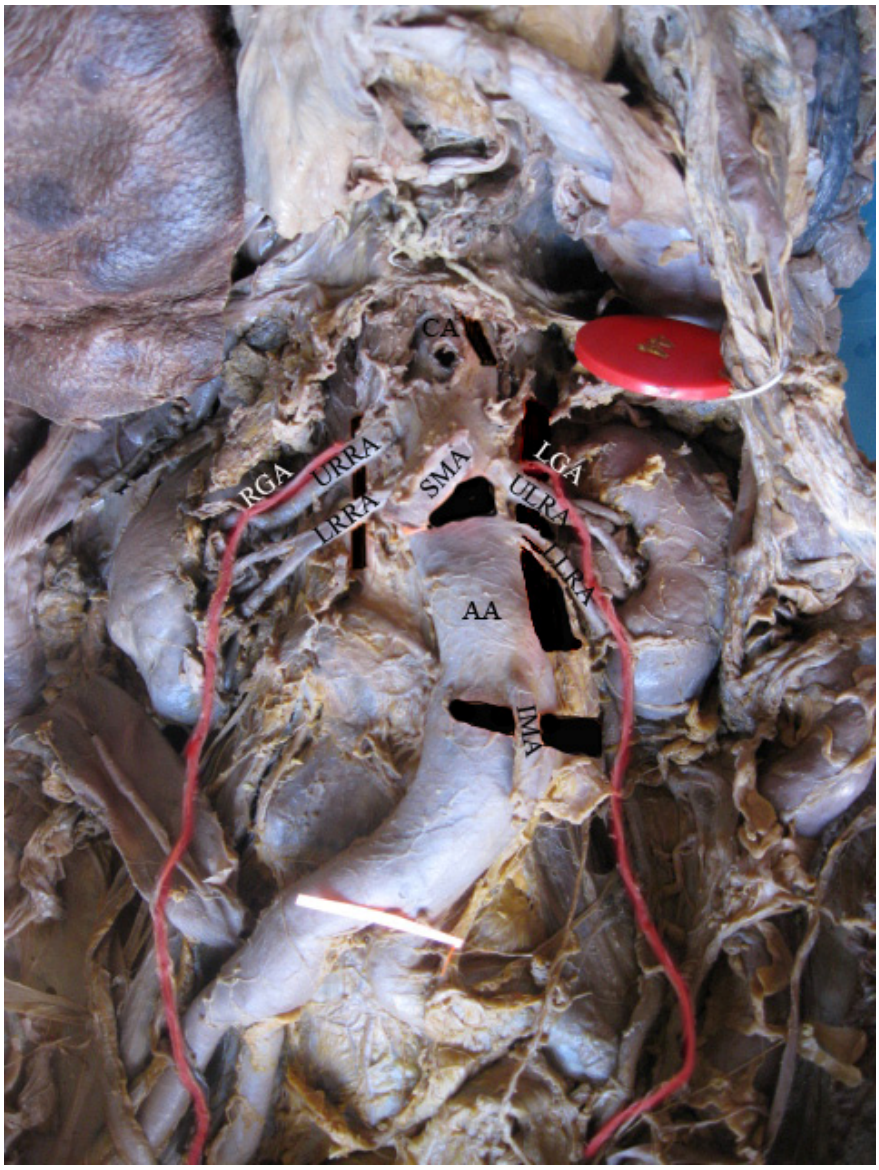


Figure: 5

- Bilateral accessory renal arteries were seen.
- Renal orgin of gonadal arteries were seen.
- Abdominal aorta shows dilatation just below the Inferior Mesenteric Artery level.

Figure: 6

Left gonadal artery arching over the left renal vein.

Figure: 7

Measurement of Diameter of AA

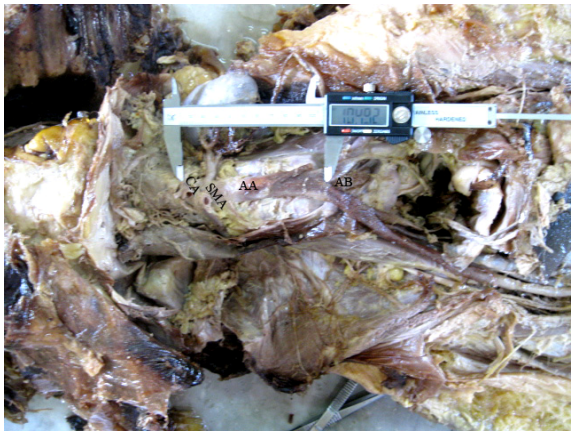


Figure: 8

Measurement of length of AA

Figure: 9

Measurement of Inter Arterial Distance of AA

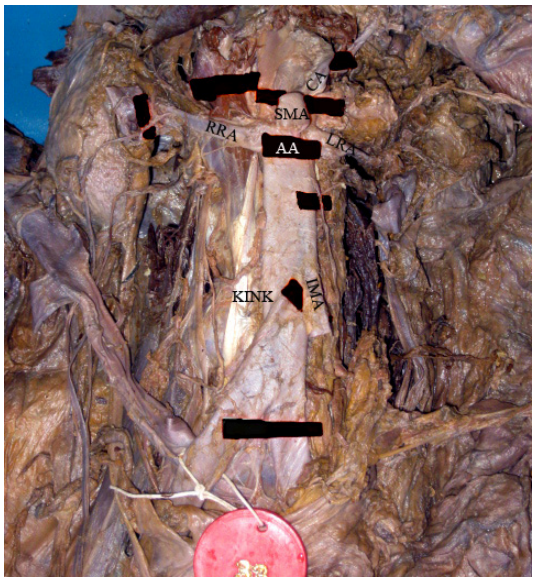


Figure: 10

Aorta shows kinking at inferior mesenteric artery level. Aorta bifurcation at higher level (lower border of 3rd lumbar vertebra).

Figure: 11

Aorta shows kinking at right renal artery level.

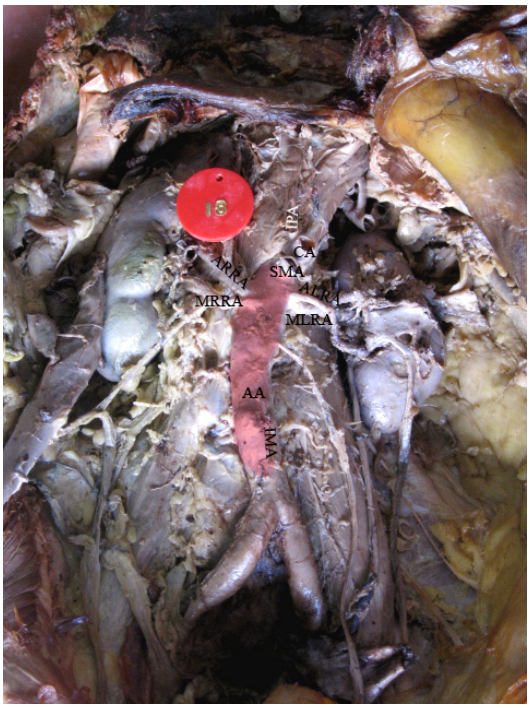


Figure: 12 & 13

Aorta shows deviation to right side.

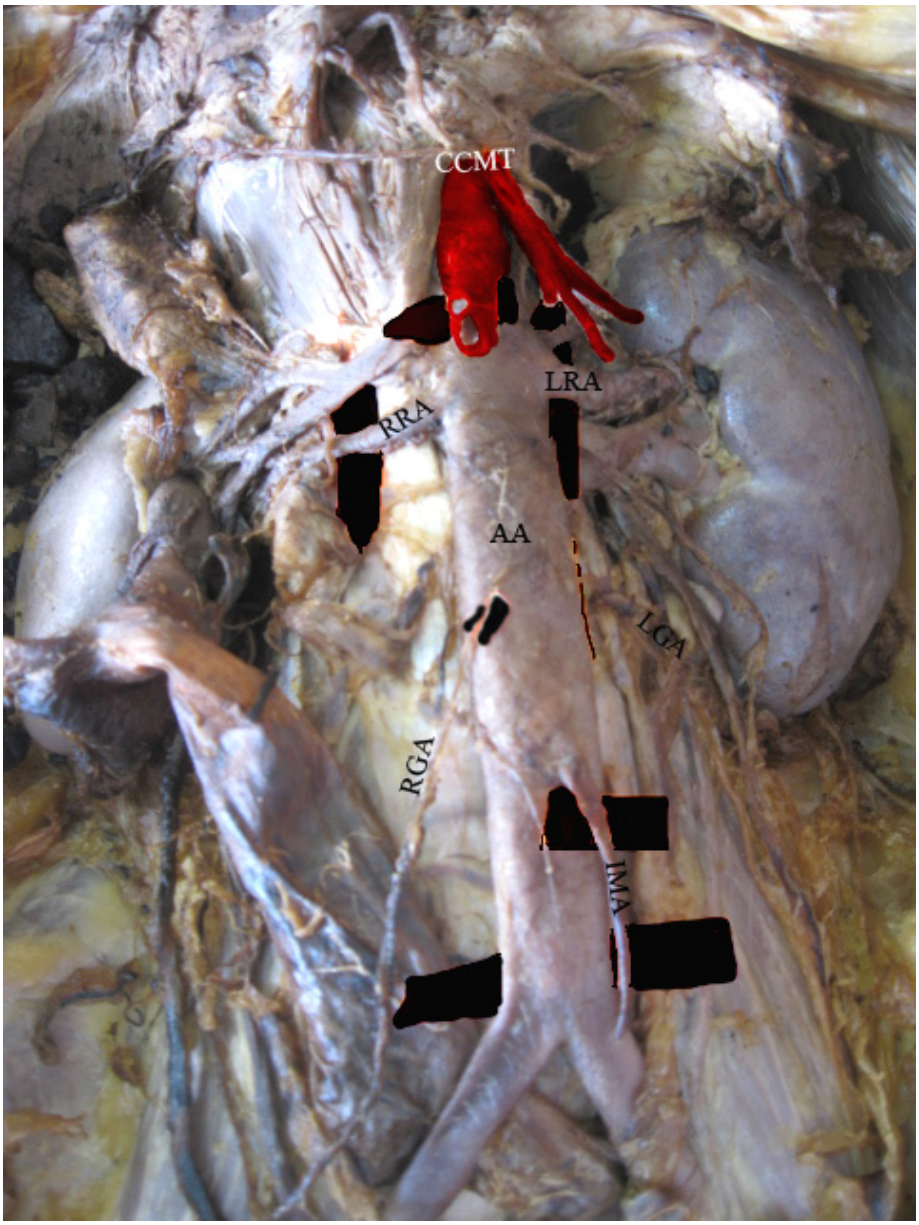


Figure: 14

Shows common Celiaco Mesenteric Trunk

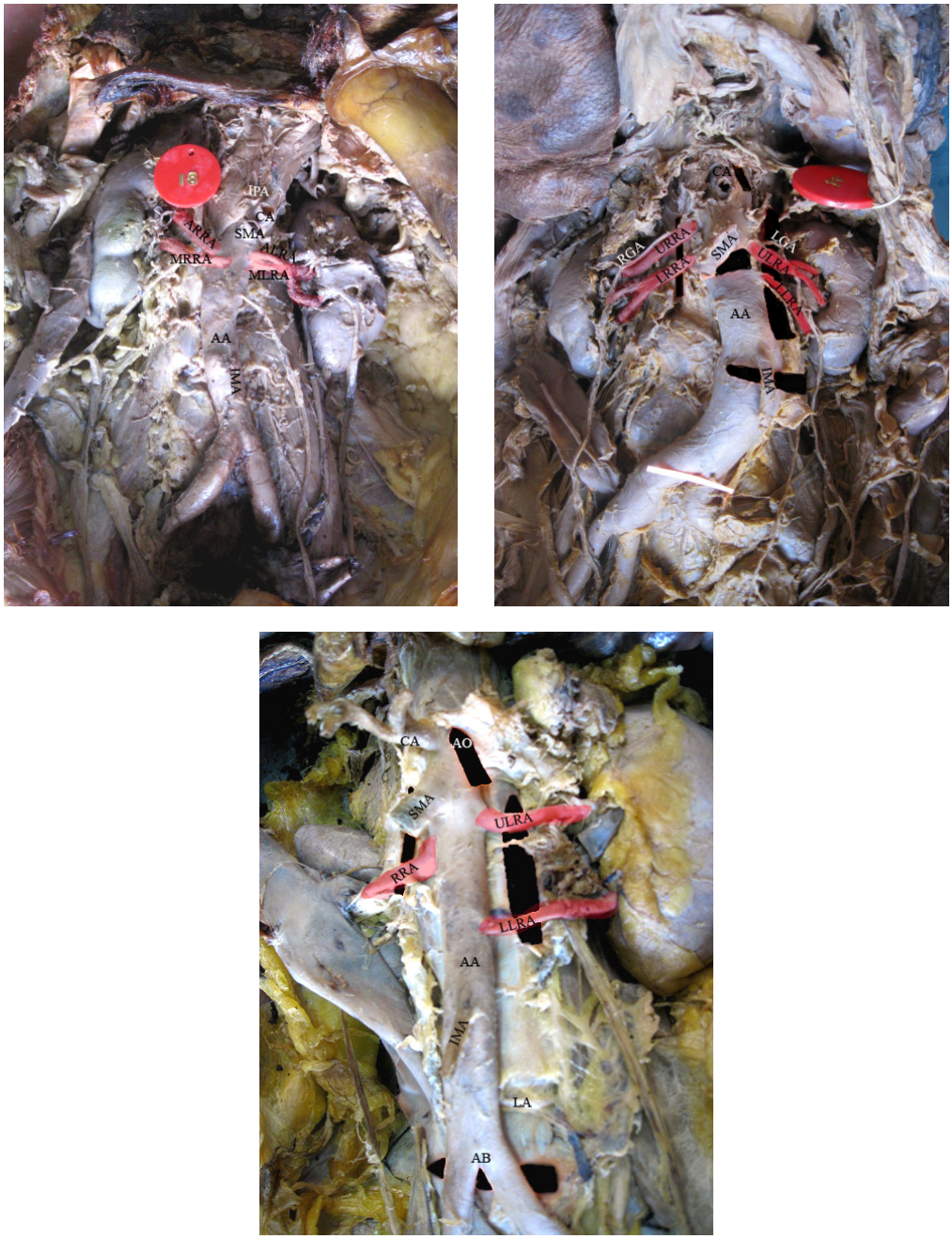


Figure: 15, 16& 17

Accessory Renal Arteries were seen

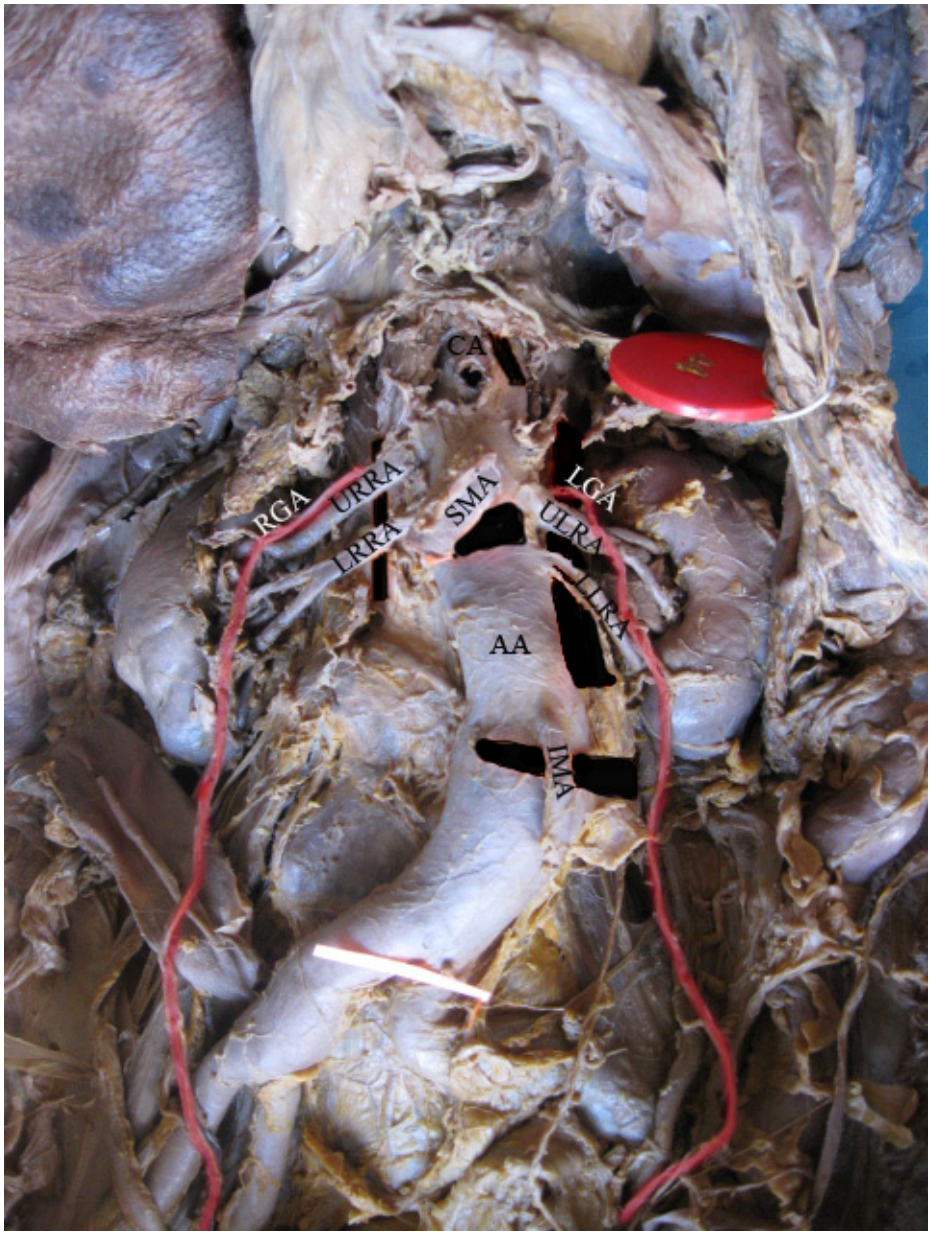


Figure: 18

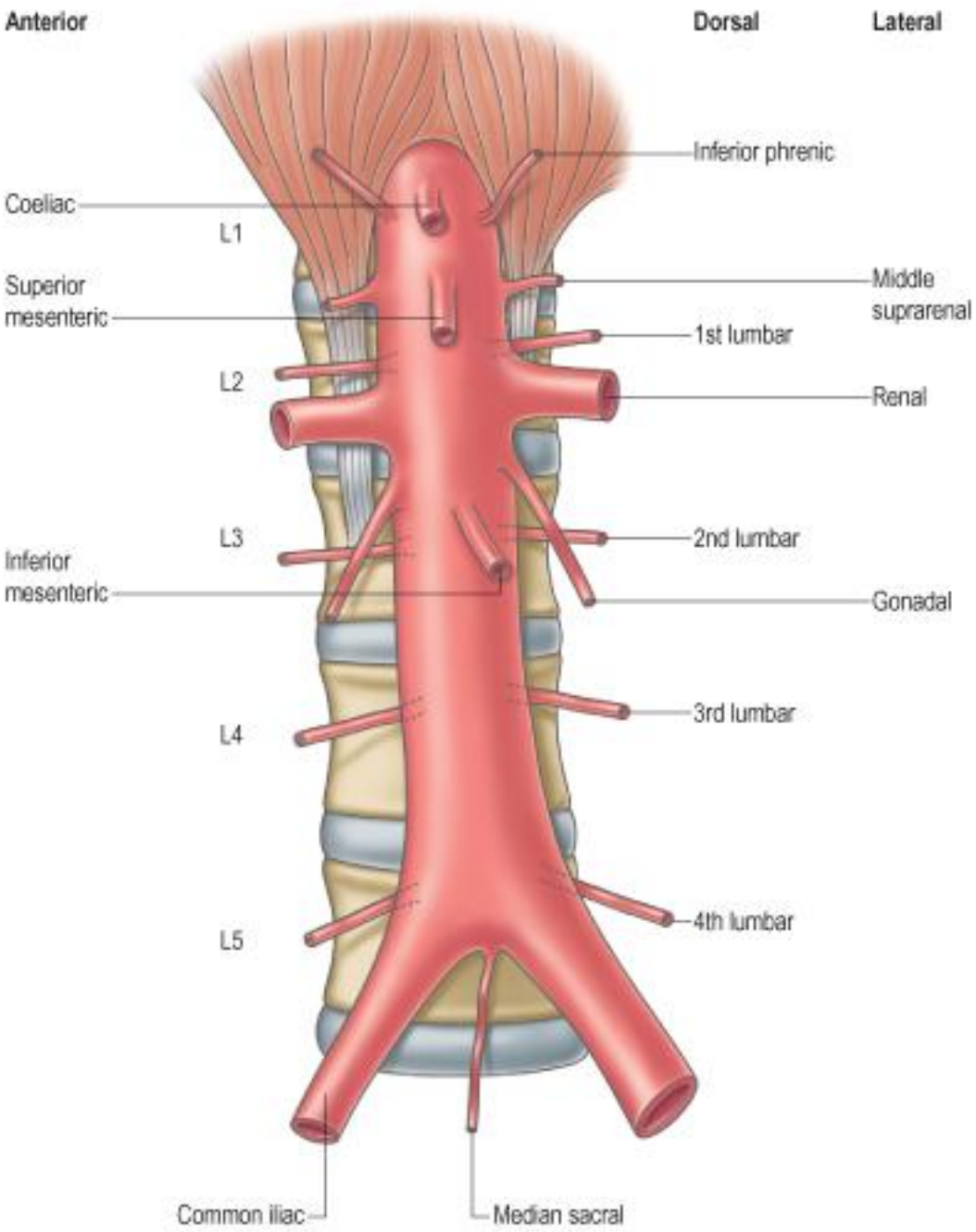
Renal origin of Gonadal Arteries were seen

Figure: 19

Figure - Shows Right Inferior Phrenic Artery, Middle Supra Renal Artery arise from renal artery from common trunk. Left Inferior Phrenic Artery from Celiac artery and left middle supra renal artery from renal artery.

Aorta specimens

ABDOMINAL AORTA



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